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PARASITES.

PARASITES;

A TREATISE ON THE

ENTOZOA OF MAN AND ANIMALS,

INCLUDING

SOME ACCOUNT OF THE ECTOZOA.

BY

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PREFACE

My introductory treatise on the Entozoa having long been out of print, it occurred to me that instead of attempting another edition it would be better to write an entirely new work, employing only such fragmentary portions of the old treatise as would harmonise with the far wider design I have now in view. Whilst, therefore, I have freely utilised a selection of the illustrations given in the elementary volume, comparatively few of its pages have been incorporated in the present work.

Dealing with parasites and parasitism after a manner not hitherto attempted I have purposely omitted minute anatomical descriptions, and, with rare exceptions, I have avoided the introduction of clinical details. While bringing to a focus the records of, and principal references to, a widely scattered, intricate, and voluminous literature, it has been my chief endeavour to supply abundance of original matter of a kind that cannot be found in the columns of any existing treatise. Whether I have succeeded or not the experienced helminthologist alone can judge. He, at all events, will perceive that the summary, though compressed within the space of a moderate-sized octavo, can only have resulted from sustained effort.

This treatise is not professional, that is to say, it does not concern itself with therapeutics or the curative treatment of parasitic affections; yet it introduces and helps to solve

many questions relating to epidemics, endemics, and epizoötics due to parasites. The medical man who only looks at the phenomena of parasitism as displayed within the human territory must of necessity acquire a cramped, narrow, and distorted conception of the rôle played by parasites in the production of disease. Let it be freely granted that to the practising physician, as such, it matters little how many beasts, birds, reptiles, or fishes perish annually from parasitic affections; yet, when it is demonstrable that a large proportion of the strictly human entozoa require a change of hosts—or, in other words, need to pass through the bodies of the lower animals—then it is evident that some acquaintance on his part with the entozoa infesting animals becomes a practical necessity. Knowledge of the kind here offered will often materially aid him in recommending prophylactic measures. Moreover, the study of comparative pathology, almost ignored in England, conveys with it other lessons of high value in relation to the healing art. The great mind of John Hunter comprehended all this long ago, as any student of the beautiful preparations contained in the museum of the Royal College of Surgeons may readily convince himself; and this is all the more noteworthy, since the subject concerns the physician rather than the surgeon.

To the naturalist the second half of this book addresses itself in a very direct manner. When engaged in his dissections, an appeal to its pages will often enable him to decide at once as to the species of parasite accidentally encountered, and if a full diagnosis be demanded it will guide him to better sources of information. Many hundreds of correspondents, not having ready access to the systematic writings of Rudolphi, Diesing, and Dujardin, have requested me to identify their "finds." I have rarely or never failed to comply with their requests; but it is hoped that the present work may prove of ready service to subsequent inquirers, and thus place a reasonable limit upon the number of future applicants. Since the manuscript of this work was completed I have received Dr von Linstow's *Compendium*

der Helminthologie, which, for the purposes held in view by the author, leaves little to be desired.

Expressly to meet the requirements of the Sanitarian I have dwelt upon the developmental phenomena exhibited by those parasites that occasion fatal helminthiases ; and, in this relation, I have not confined my remarks to the parasites that are injurious to man in a direct manner, but have extended my observations to the genesis of those entozoa that prove destructive to horses, to beasts of burden generally, and to other creatures which, like cats and dogs, are in various ways subservient to man's wants. It will be seen that in this way several questions relating to the purity of water and flesh-food, respectively, have been incidentally brought under notice.

In view of the magnitude of the task which my enthusiasm, perhaps unwarrantable, has led me to undertake, I know full well how considerately my foreign friends and correspondents will deal with the errors of omission and commission that they will certainly detect in these pages. If there be any educated persons at home who still affect to despise the revelations of helminthology, I can assure them that their prejudices are misplaced. The study of the structure and economy of a humble parasite brings to the investigator no slight insight into the workings of nature. If these workings cannot at all times be pronounced to be "good and beautiful," they must at least be characterised as "true." The knowledge of the true —especially if that knowledge by its practical applications be calculated to confer substantial benefits upon man and his inferior fellow-creatures—ought to be held in high esteem; but, apart from this purely utilitarian view, there remains for the investigator the delight occasioned by the in-rush of new scientific ideas. The average mind, being either essentially commercial or ridiculously sentimental, as the case may be, is totally incapable of comprehending the motive power that animates and guides the votary of science. The late Professor Faraday, a

man wholly untinged by the ambitions of wealth and power, once remarked to me that there were no people so difficult to instruct as those who were ignorant of their own ignorance. It is just these very persons who, when placed in high positions of social, political, or professional trust, most powerfully contribute to check a nation's progress. There are too few genuine workers at science in this country. As one of the rank and file, I claim only to have honestly contributed my mite. I should like to see a small army of helminthologists rise up and lay siege to the fortresses at present securely held by thousands of death-dealing parasites.

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74, Portsdown Road, London
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ERRATUM.

Page 296, line 24 from the top, for "in the glow-worm (*Glomeris*)," read "in a myriapod (*Glomeris*) which is phosphorescent like the glow-worm."

PARASITES.

INTRODUCTION.

No person can derive advantage from the study of parasites unless the subject be approached in a right frame of mind. In other words, the student of helminthology must, as a primary discipline, dispossess himself of all preconceived opinions whatsoever, and in an attitude of child-like simplicity seek truth for its own sake. Unless the mind be absolutely free and unfettered it cannot rightly interpret the facts of this peculiar department of biological science. Those students who are nervously anxious to reconcile the conclusions of modern science with the ideas of their forefathers are certain to remain just as ignorant of the true value and significance of nature-teachings as all their fathers were.

Whether dealing with the external or internal forms, the study of parasites of man and animals is practically one of boundless extent; and there is probably no department of knowledge, possessing an equal value in relation to the welfare of man and beast, that is so thoroughly misunderstood by those who are directly concerned in the appreciation of its revelations. This has arisen from a total misconception as to cause and effect. Most people, not excluding even the votaries of the healing art, following tradition, regard the internal parasites or entozoa as creatures either directly resulting from certain diseased conditions of their *hosts* or as organisms which would not have existed if their *bearers* had been perfectly healthy. Nothing can be more absurd. Such a conclusion is utterly at variance with all logical deduction from known facts. It is, however, quite on a par with multitudes of other popular

delusions which, in spite of the advance of science, will probably never become wholly eradicated from the public mind. People who hold these notions either cannot or do not desire to reject a view which has for them a dominating power almost equal to that of any known religious dogma. In conversation I have repeatedly noticed this to be the case. These people are the victims of educated ignorance and they will never allow that parasites are natural developments, accomplishing ends or parts of the orderly mystery which reigns everywhere. Some of them still cling to the creed that the presence of parasites, of internal ones at least, betokens evidence of Divine disfavor; and their minds are troubled with all sorts of distressing and childish conceptions. In the present age one would have thought that such ridiculous ideas could not be seriously maintained; but instead of being relegated to the limbo of similar "old wives' fables" they dominate the opinions of thousands of our so-called educated people. The genuine searcher after truth does not need to be told that all preconceptions of this order hopelessly obscure the mental vision. They operate to render a just and adequate understanding of the science of helminthology impossible. The biologist may say what he lists, but he knows perfectly well that the superstitious mind will continue to ignore the precious and elevating results of scientific research, and that it will perseveringly continue to persuade itself that internal worms, parasites, and entozoa, of whatever kind, belong to the category of "plagues" liable to be distributed as special punishments for human wrong-doing.

As remarked in my previous treatise, the best way of studying the entozoa is to regard them as collectively forming a peculiar *fauna*, destined to occupy an equally peculiar territory. That territory is the wide-spread domain of the interior of the bodies of man and animals. Each bearer or "host" may be viewed as a continent, and each part or viscus of his body may be regarded as a district. Each district has its special attractions for particular parasitic forms; yet, at the same time, neither the district nor the continent are suitable as permanent resting-places for the invader. None of the internal parasites "continue in one stay;" all have a tendency to roam; migration is the soul of their prosperity; change of residence the essential of their existence; whilst a blockade in the interior soon terminates in degeneration and death. I repeat it. The entozoa constitute a specialised fauna. What our native country is to

ourselves, the bodies of animals are to them. To attack, to invade, to infest, is their legitimate prerogative. Their organisation, habits, and economy are expressly fashioned to this end. How remarkable and complex is their structure, and how peculiar, diverse, and varied are their ways and wanderings, the contents of this volume will, I trust, sufficiently explain. The puerile horror which even some scientific persons affect to display in regard to the subject is altogether out of place. To the rightly balanced mind the study of these much abused "worms" is just as attractive as any other section of zoology. Helminthology opens up to our view many of the strangest biological phenomena of which the human mind can take cognisance; whilst a profound and extended knowledge of the subject, in all its bearings, is calculated to secure to the community a rich practical reward by enabling us to do effectual battle with not a few of the many ills of life to which our flesh is heir.

Further on the general advantages to be derived from the study of parasites I cannot here dilate, and it becomes the less necessary that I should do so, since I have entered upon the subject very fully elsewhere. The character of the present work, moreover, imposes brevity. If the plan which I now propose to follow should not be deemed altogether satisfactory from the purely zoological standpoint, it will nevertheless have the advantage of simplicity and novelty; and knowing full well the difficulties that must surround any attempt to give a perfect classification of the entozoa, considered as a natural group, I feel sure that my helminthological friends will credit me with exercising a wise discretion in selecting the simplest available method of arrangement. My plan, therefore, is to devote separate sections of this work to the parasites of the different classes of vertebrated animals, including man, treating of the various species in regular succession. This arrangement is merely one of convenience and has no reference whatever to conceptions of zoological equivalency as variously interpreted and maintained by authors and investigators. The parasitic groups will be taken up in the following order, quite irrespective of their relative importance, and also without any attempt to treat each group with equal fulness. In the matter of recent literature only will the present record and summary make any approach toward completeness, my hope being to render this treatise indispensable and trustworthy as a ready means of reference.

I. Flukes. Trematoda.—This group embraces several families of parenchymatous worms. The various species exhibit one or more suckers, which the older naturalists regarded as so many mouths or *perforations*. Hence the ordinal title. The term fluke is of Saxon origin, meaning anything flat. Thus, it has been applied to sole-fish or flounders, to the flattened halves of the tail of cetaceans, to the blades of anchors, and so forth. Although the common liver fluke is flat, many species of the order are round, biconvex, or even filiform organisms. I recognise six families :—*Monostomidæ, Distomidæ, Amphistomidæ, Tristomidæ, Polystomidæ*, and *Gyrodactylidæ*. Most of the species are entozoal; but many adhere to the surface of the body of piscine hosts.

II. Tapeworms. Cestoda.—This comprises not only the tapeworms, but also the measles and other bladder-worms or cystic Entozoa of the old authors (Cystica). The Greek word *kestos* means a band or girdle; hence the ordinal term above given. The bladder-worms, including Hydatids, Cysticerci, &c., are the larval stages of growth of various tapeworms. The further reduction of this order into sub-orders or families requires careful attention. At present we have *Tæniadæ, Acanthotæniadæ, Dibothridæ* (=*Bothriocephalidæ*), *Diphyllobothridæ, Tetrarhynchidæ*, and *Tetraphyllobothridæ*. All the genera and species are entozoal. The proposal to separate the snouted or proboscidiform tapeworms (*Rhynchotæniadæ*) from those in which the rostellum is absent (*Arhynchotæniadæ*) does not recommend itself to my judgment.

III. Roundworms. Nematoda.—This series comprises not only lumbricoid or roundworms proper, but also threadworms. The term derives its origin from the Greek word *nema*, signifying a thread. It likewise includes the strongyles, the term *stronqulos* meaning round or cylindrical. This is a very extensive group whose parasitic members are strictly entozoal, whilst the non-parasitic forms are either entirely free or they infest plants. Some of the so-called free nematoids live in the slime of animals. The artificial classification by Schneider, based on the muscular system, places these parasites in three well-marked groups, but I think it a disadvantage to separate widely many really closely allied forms. Thus, in his *Polymyarii* we have the genus Eustrongylus, and in his *Meromyarii* the Strongyli proper. Most of the genera may be fairly included in the following families :—*Ascaridæ, Cheiracanthidæ, Cucullanidæ,*

Strongylidæ, Trichinidæ, Oxyuridæ, Trichocephalidæ, Filaridæ, Gordiidæ, Anguillulidæ.

IV. Thornheaded-worms. Acanthocephala.—This group embraces a small series of parasites, which, in general appearance, resemble the nematode worms. They differ, however, essentially, being, as the term indicates, furnished with spine-covered heads. They are, moreover, destitute of digestive organs. The species are entozoal in habit, abounding particularly in fishes and reptiles. At present, all the known forms are included in one family (*Echinorhynchidæ*), which also comprises only a single genus.

V. Annelid parasites. Suctoria.—In this category one must place all such suctorial annelids as affix themselves to hosts for a longer or shorter period. Many of the leech-like parasites (*Clepsinidæ*, and especially *Mallacobdellidæ*) remind one of certain flukes (*Tristoma*, &c.) possessing ectozoal habits; whilst the leeches, properly so called, afford instances of the passage from a semi-parasitic to what has been called the free parasitic mode of existence. In tropical countries these creatures very readily attach themselves to man and animals, often creating severe distress. The genera *Clepsine* and *Hæmocharis* attack mollusks and fishes respectively. The species are all ectoparasitic and exceedingly numerous. They cannot be described in this work.

VI. Arachnid parasites. Arachnida (part of).—The great class of articulated, limb-jointed, or, more strictly, arthropodous animals, includes a variety of parasites. The mites, true ticks, and such like creatures, belong to this group. Some few of them are entozoal in habit, others are only partially so, whilst the majority are entirely ectozoal. Of the two great sections of Arachnida, namely, Pulmonaria and Trachearia, the latter alone contains strictly parasitic forms. The parasitic species belong to the following families:—*Pentastomidæ, Pycnogonidæ, Ixodidæ, Acaridæ, Gamasidæ, Hydrachnidæ, Solpugidæ.* The parasitism of some of the species is very partial or slight. Thus, certain of the water mites, in their juvenile state, dwell on aquatic insects only; and the tick-like *Gamasidæ* occur upon dung-beetles. The other ectozoal species attack vertebrated animals, and several attach themselves to man himself. The whale lice (*Cyamidæ*) are here included in the *Pycnogonidæ*, though often placed by zoologists with the Crustaceans.

VII. CRUSTACEAN PARASITES. CRUSTACEA (part of).—A large number of species belonging to various well-marked sections of this great class of Invertebrates are parasitic in their habits, most of them being comprised in the so-called haustellated group. They are familiarly known to zoologists as Epizoa. As this latter term implies, they are strictly ectozoal in character, most of the species victimising fishes by attaching themselves, not only to the general surface of the body, but also to the eyes, and especially to the gills or branchiæ. The species for the most part belong to the families *Lernæidæ, Caligidæ, Dichelestidæ,* and *Argulidæ.* In this category must likewise be placed two other families belonging to the so-called isopodous section of edriophthalmatous crustaceans. These are the *Cymothoidæ,* which attach themselves to the tails of fishes, and the *Bopyridæ,* which occupy the branchial cavity of shrimps. The nature of this work precludes any detailed notice of the numerous members of this section.

VIII. INSECT PARASITES. INSECTA (part of).—The insects, properly so called (that is to say, arthropodous, evertebrated creatures, with six legs), are many of them essentially parasitic in their habits. The most important of these are "bots" and other larvæ or maggots of various flies (Diptera). The varieties of lice are also included in this group. Some few of the insect parasites are strictly entozoal in habit, at least for a part of their lifetime, being previously attached externally for a short period only. Most of the forms are essentially ectozoal. A very large number of insect tormentors, although deriving nourishment from their victims, attach themselves to the animals for so short a time that they cannot be classed as parasites under the ordinary acceptation of the term. As examples of the so-called free parasitism, the autumnal flies (*Tabanidæ*) and *Stomoxys* may be cited. Although embracing but few strictly parasitic forms we have the following :—*Œstridæ, Hippoboscidæ* (with *Melophagus*), and *Nycteribiidæ.* In regard to the maggots of *Muscidæ* and *Sarcophagæ,* some of them are parasitic on animals and man, whilst others are parasitic upon insects themselves. The larvæ of *Conopidæ* attack humble-bees internally. Those parasitic insects, properly so called, which, like certain of the crustaceans, are sometimes spoken of as epizoa, comprise three well-marked families. Thus, we have *Pediculidæ* (the source of lousiness), *Philopteridæ,* and *Liotheidæ.* Both of the latter embrace numerous

species which for the most part content themselves with devouring the feathers of birds and the hairs of quadrupeds. In addition to these it may be added that some of the rat-tailed larvæ or Helophilus maggots (*Syrphidæ*) are parasitic in man and quadrupeds, as are also the larvæ of the churchyard beetle (*Blaptidæ*). The closely allied *Tenebrionidæ* and other coleopterous families also supply various maggots possessed of parasitic habits. Fleas and bugs come under Van Beneden's category of free parasites. This is equivalent to calling them non-parasitic parasites, an expression which looks very like a contradiction of terms.

IX. Protozoal Parasites. Protozoa (part of.)—This miscellaneous assemblage of minute creatures embraces a number of parasites of very low organisation. In the present work it is neither desirable nor necessary to hazard any statements respecting their precise zoological position. It is sufficient to say that the parasitic protozoa are for the most part entozoal in habit, not a few of them possessing vegetable affinities. The microscopic *Bacteridæ*, *Gregarinidæ*, and *Psorospermiæ*, comprise a multitude of organisms which are strictly parasitic in their habits, whilst amongst the *Infusoria* we find numerous forms which, though dwelling in the intestinal canal of their hosts, do not derive nourishment in a direct manner from their bearers. Of this kind are *Paramecium* and *Balantidium*. The separation of the psorospermiæ and gregarinæ into genera is attended with difficulty; nevertheless, I have for convenience long recognised various types under titles corresponding with the names of the observers who first discovered them (*Hesslingia*, *Gubleria*, *Lindermannia*, and so forth). Of necessity, the protozoal parasites will only be incidentally noticed in this work. In this category I place the falsely so called "cattle-plague bodies." The micrococci and bacteria hardly come within the province of the helminthologist.

Without prejudice to the foregoing restrictions I must at the same time observe that the varied characters presented by the above-mentioned groups show how impossible it is to treat the subject of parasitism adequately, if one is obliged to confine his remarks to the internal parasites or helminths proper. Many creatures possessed of entozoal and ectozoal habits are parasites in every legitimate sense of the term, and yet they do not belong to the class *Helmintha* in its common zoological acceptation. *That* class taken by itself may still be allowed to stand pretty

much as I represented it in 1864; but in the present work I cease to speak of the Entozoa as in any sense the zoological equivalent of the *Helmintha*. I prefer to employ the term Entozoa in its popular and wider acceptation. It conveniently stands thus, moreover, in direct contradiction to the term Ectozoa.

As this work treats of parasites only, I purposely refrain from dealing with the Turbellarians, and certain other creatures usually classed with *Vermes*. The vague term "worms," so often employed as the equivalent of *Helmintha*, is misleading in many ways. I should like to see it adopted only when speaking of the Annelids proper. It would still have a sufficiently wide application, seeing that it would include Leeches, Earthworms, Naids, Tubed-worms, Sea-lobworms, Sea-mice, Nereids, and a host of other setigerous species. Notwithstanding the remote connection subsisting between "intestinal worms" and worms properly so called, the notion that an intimate relation subsists between the lumbricoid helminths and earthworms will probably never entirely disappear from the popular or even from the professional mind.

Since one of the principal features of this treatise is to afford a handy means of reference to the rich and extended literature of parasitism, I here subjoin a list of general and systematic treatises. To most of these I shall constantly refer. Full special references to detached memoirs will appear in the bibliographies scattered throughout the body of the work.

Bibliography (No. 1).—*Bremser*, 'Ueber lebende Würmer im lebenden Menschen,' Vienna, 1819; French edit., by Grundler, 1824.—*Idem*, 'Icones helminthium,' Vienna, 1824.—*Cobbold, T. S.*, 'Entozoa, an Introduction to the Study of Helminthology, with reference more particularly to the Parasites of Man,' London, 1864; Supp., 1869.—Reviews in the 'Lancet,' Sept. 24th, 1864, p. 353; in the 'Med. Times and Gaz.,' Oct. 29th, 1864, p. 474; in the 'Athenæum,' Oct. 15th, 1864, p. 493; in 'Cosmos,' Oct. 27th, 1864, p. 463; in the 'Reader,' Nov. 26th, 1864, p. 668; in the 'Edinburgh Vet. Review,' Nov., 1864, p. 662; in 'Intellectual Observer,' vol. vi, 1864, p. 190; in the 'Quarterly Journal of Science,' No. v, January, 1865, p. 145; in the 'Quart. Journ. of Micr. Science,' New Series, No. 17, Jan., 1865, p. 43; in 'Popular Science Review,' Jan., 1865, p. 214; in the 'Veterinarian,' Feb., 1865, p. 97; in the 'Medical Mirror,' Jan., 1865, p. 23; in the 'Natural History

Review' for July, 1865; in the 'British and Foreign Medico-Chirurgical Review,' April, 1865, in the 'Edinburgh Medical Journal' for April, p. 929; in the 'Social Science Review' for Feb. 1, 1866, p. 169; in 'Dublin Quart. Journ. of Medical Science' for Aug., 1867.—*Davaine, C.*, 'Traité des Entozoaires et des maladies vermineuses de l'homme et des animaux domestiques,' Paris, 1860, 2nd edit., 1877-79.—*Diesing, C. M.*, 'Systema helminthum,' Vienna, 1850.—*Dujardin, F.*, 'Histoire naturelle des helminthes ou vers intestineaux,' Paris, 1845.—*Goeze, T. A. S.*, 'Versuch einer Naturgeschichte der Eingeweidewürmer thierischer Körper,' Blankenburgh, 1782.—*Küchenmeister, F.*, 'Die in und an dem Körper des lebenden Menschen vorkommenden Parasiten,' Leipsic, 1855, 2nd. edit., 1878-79; Eng. edit., by Lankester, 1857.—*Le Clerc, D.*, 'A Natural and medicinal History of Worms bred in the bodies of men and other animals' (*sic*), Browne's edit., London, 1721.—*Leuckart, R.*, 'Die menschlichen Parasiten, und die von ihren herruhrenden Krankheiten,' Leipsic und Heidelberg, 1863-1876.—*Redi, F.*, 'De animalculis vivis quæ in corporibus animalium vivorum reperiuntur, observationes;' Coste's edition, Amstelædami, 1688.—*Rudolphi, C. A.*, 'Entozoorum sive vermium intestinalium historia naturalis,' Amsterdam, 1808.—*Idem*, 'Entozoorum Synopsis,' Berlin, 1819.—*Van Beneden, P. J.*, 'Animal Parasites and Messmates,' London, 1876.

Several of the above works, while professing to deal with human parasites only, cover more or less of the whole ground of helminthology. Leuckart's work is invaluable in this respect; and in the matter of literary references of a professional kind Davaine's treatise is itself well nigh exhaustive. In any ordinary volume it is not possible to give a complete bibliography of parasitism. I make no pretension to do so here; nevertheless, the large number of modern memoirs that I have received from the distinguished writers themselves, enables me to render this part of my book very useful. As second only in importance to the above-mentioned works may be added the following—whether minor treatises, memoirs, monographs, comprehensive articles, or reports of a general or special character, respectively. As such it will be seen that some of them are sufficiently comprehensive, and their mere enumeration will enable the beginner to realise something like a fair estimate of the scope of helminthology. In the case of my own works I have ventured to add references to reviews

and notices, because many of the latter contain valuable original suggestions made by the various anonymous writers.

Bibliography (No. 2).—*Bastian, H. C.*, "On the Anatomy and Physiology of the Nematoids, parasitic and free," 'Philosophical Transactions,' 1865 (see also Bibliog., No. 60).—*Cobbold, T. S.*, 'Worms; a series of lectures on Practical Helminthology,' London, 1872; Italian edition by Tommasi. Milan, Florence, &c., 1873.—*Idem*, 'The Internal Parasites of our Domesticated Animals,' London, 1873; Italian edit. by Tommasi, Florence, 1874.—*Idem*, 'Tapeworms (Human), their Sources, Varieties, and Treatment,' London, 3rd edit., 1875. Reviews (1st and 2nd edit., with 'Threadworms'), in 'Brit. and For. Med.-Chir. Review' for 1867, p. 433; in 'Edin. Med. Journ.' for 1866-67, p. 107; in 'Lancet,' Nov. 10th, 1866; in 'Popular Science Review,' Oct. 1st, 1866; in 'Intellectual Observer,' Oct. 1866; in 'Med. Press and Circular,' Jan. 16th, 1867; again in the 'Lancet,' for March 13th, 1867; and in 'Dublin Quart. Journ. of Medical Science' for 1867, 3rd edit.; in the 'Field,' Sept. 25th, 1875; and in 'Popular Science Review' for Jan., 1876.—*Idem*, 'Catalogue of the Specimens of Entozoa in the Museum of the Royal College of Surgeons of England,' London, 1866; noticed in the 'Lancet' for March 24th, 1866, p. 321.—*Idem*, "On the best Methods of displaying Entozoa in Museums," 'Journ. Linn. Soc.,' vol. viii, p. 170.—*Idem*, 'New Entozootic Malady,' &c., 1864; popular brochure, reviewed in the 'Lancet,' Feb. 4th, 1865, p. 128; in the 'Athenæum,' Jan. 21st, 1865, p. 87; in the 'British Med. Journal,' Jan., 1865; in the 'Veterinary Review and Stockowners' Journal,' No. 2, New Series, Feb., 1865, p. 76; in the 'Reader,' Feb. 4th, 1865, p. 142; in 'Med. Times and Gaz.' for June 2nd, 1865; in the 'Field' for March 18th, 1865.—*Idem*, "Parasites of Man," forming a series of articles contributed to the 'Midland Naturalist,' 1878-79.—*Idem*, "Notes on Entozoa contained in the various Metropolitan Museums," in 'Lancet,' May 13th, 1865, p. 503.—*Idem*, "Report on *Plica polonica*, in reference to Parasites," in 'Pathological Soc. Trans.,' 1866, p. 419.—*Idem*, "Report on Experiments respecting the Development and Migrations of the Entozoa," 'British Assoc. Reports' (Bath Meeting) for 1864, p. 111; and briefly noticed in 'Lancet' for Sept. 24th, 1864.—*Idem*, Miscellaneous observations, including "Note on Parasites in the Lower Animals," in 'Dub. Med. Press' for Feb. 11th, 1863, p. 154.—*Idem*,

"Vegetables, Fruits, and Water considered as sources of Intestinal Worms;" in the 'Popular Science Review' for Jan., 1865, p. 163.—*Idem* (anonymously), "On Comparative Pathology and Therapeutics" (in relation to Entozoötics); leading art. in 'Lancet' for Dec. 9th, 1865, p. 652.—*Idem*, "List of Entozoa, including Pentastomes, from animals dying at the Zoological Society's Menagerie, between 1857-60 inclusive, with descriptions of several new species," 'Proc. Zool. Soc.,' 1861.—*Idem*, "Remarks on all the Human Entozoa," 'Proc. Zool. Soc.,' 1862; abstracts in 'Brit. Med. Journ.' for 1862, and in 'Edinb. New Phil. Journ.,' vol. xvii, new series, 1863, p. 145; in Report of the 'Proceed. of the Brit. Assoc. at Cambridge,' 1862.—*Idem*, "Our Food-producing Ruminants, and the Parasites which reside in them; being the Cantor Lectures of the Society for the Encouragement of Arts, Manufactures, and Commerce," delivered in 1871, and pub. in the 'Journal of the Soc. of Arts' for that year.—*Davaine, C.*, "Les Cestoïdes," in 'Dict. Encycl. des Sci. Med.,' Paris, 1876.—*Eberth, C. J.*, 'Untersuchungen ueber Nematoden,' Leipsic, 1863.—*Heller, A.*, "Darmschmarotzer," in Von Ziemssen's 'Handbuch,' Bd. vii, 1876; and in the American edition of the same, 1877.—*Jones, T. R.*, "List of Entozoa of Greenland," taken from *Krabbe*; 'Arctic Manual,' 1875, p. 179.—*Krabbe, H.*, 'Helminthologiske Undersogelser,' Copenhagen, 1865.—*Leuckart, R.*, 'Die Blasenbandwürmer und ihre Entwicklung,' Giessen, 1856.—*Moquin-Tandon, A.*, "Epizoa and Entozoa," in Hulme's edit. of his 'Elements of Medical Zoology,' London, 1871.—*Nordmann, A. von*, 'Mikrographische Beiträge zur Naturgeschichte der wirbellosen Thiere,' Berlin, 1832.—*Olsson, P.*, "Entozoa, iakttagna hos Skandanaviska hafsfiskar.," Lund, 'Univ. Årsskrift,' 1867.—*Owen, R.*, "Entozoa," art. in Todd's 'Cyclopædia of Anat. and Physiol.,' London, 1839.—*Idem*, "Entozoa," 'Lectures (iv and v) on the Comp. Anat. and Physiol. of the Invertebrate Animals,' London, 1855.—*Pagenstecher, H. A.*, 'Trematodenlarven und Trematoden,' Heidelberg, 1857.—*Rhind, W.*, 'A Treatise on the Nature and Cure of Intestinal Worms, &c.,' London, 1829.—*Rolleston, G.*, "Characteristics of Nematelminthes and Platyelminthes," in his 'Forms of Animal Life,' Oxford, 1870.—*Schneider, A.*, 'Monographie der Nematoden,' Berlin, 1866.—*Siebold, C. von*, "Parasiten," art. in Wagener's 'Handwörterbuch der Physiol., &c.,' 1845.—*Idem*, "Helminthes," Book v, in Burnett's edit. of Siebold and Stannius' 'Comparative Ana-

tomy,' London and Boston, 1854.—*Thomson, A.*, "Entozoa," in the art. "Ovum," in Todd's 'Cyclop. of Anat. and Physiol.,' London, 1859.—*Van Beneden, P. J.*, 'Mémoire sur les Vers Intestineaux,' Paris, 1858.—*Idem*, "Les Vers Cestoïdes," 'Mém. de l'Acad. Roy.,' Brussels, 1850.—*Verrill, A. E.*, "The External and Internal Parasites of Man and the Domestic Animals," 'Rep. of Board of Agriculture,' Connecticut, U.S., 1870.—*Von Baer, K. E.*, 'Observations on Entozoa;' in an analytical notice of his article "Beiträge zur Kentniss der niedern Thiere," from 'Nova Acta Nat. Cur.,' tom. xiii, in the 'Zool. Journ,' vol. iv, p. 250, 1828-29.—*Wagener, G. R.*, 'Beiträge zur Entwicklungsgeschichte der Eingeweidewürmer,' Haarlem, 1857.—*Weinland, D. F.*, 'An Essay on the Tapeworms of Man,' Cambridge, U.S., 1858.

BOOK I.

PARASITES OF MAN.

Whatever notions people may entertain respecting the dignity of the human race, there is no gainsaying the fact that we share with the lower animals the rather humiliating privilege and prerogative of entertaining a great variety of parasites. These are for the most part entozoal in habit. As the parasites are apt to cause suffering to the bearer, a superstitious age sought to interpret their presence as having some connection with human wrong-doing. We can now afford to smile at such erroneous ideas. The intimate relation subsisting between parasitic forms dwelling in man and animals, and their inter-dependence upon one another, alone suffices to preclude the idea that parasites have been arbitrarily placed within the human bearer. It would seem, indeed, that our existence is essential to the welfare and propagation of certain species of parasites. Possibly it is only by accepting the hypothesis of "Natural Selection" that we can escape the somewhat undignified conclusion that the entozoa were expressly created to dwell in us, and also that we were in part designed and destined to entertain them. View the matter as we may, the internal parasites of man and animals strictly conform to a few well-known types of structure, but these types branch out into infinitely varied specific forms. The vulgar mind sees nothing attractive in the morphology and organisation of a parasitic worm, and common-place conceptions of the beautiful cannot be expected to embrace within their narrow grasp the marvellous harmony and order that pervade the structure and economy of the individual members of this remarkable class of beings.

SECTION I.—Trematoda (Flukes).

Fasciola hepatica, Linneus.—The first form I have to consider is the common liver fluke. The part this entozoon plays in the production of disease will be fully stated when treating of the parasites of the sheep and other ruminants. About twenty instances of its occurrence in the human body have been recorded. It has been found beneath the skin in the sole of the foot (Giesker), and also under the scalp (Harris), and behind the ear (Fox). Its more frequent seat is in the liver and gall-ducts (Pallas, Brera, Bidloo, Malpighi) and gall-bladder (Partridge). The alleged cases by Bauhin, Wepfer, and Chabert are spurious, as is probably also that given by Mehlis. Duval's case appears to be genuine, but the occurrence of the worm in the portal vein was accidental. Dr Murchison has recorded a case, occurring at St Thomas's Hospital, where a solitary specimen was found in the liver. Dr H. V. Carter also met with the worm in a young Hindoo.

In the second half of the present work I shall reproduce Blanchard's admirable figure of the sexually mature worm (Fig. 61), accompanied by a categorical statement respecting the known facts of development. In this place, however, I may observe that the cases recorded by Giesker, Harris, and Fox had clearly pointed to the circumstance that the higher larvæ of this fluke must be armed cercariæ, otherwise they could not have bored their way through the human skin. As we shall see, Dr Willemoes-Suhm's investigations have furnished evidence as to the truth of this supposition. For anatomical details I refer to my introductory treatise. In the adult state the liver fluke has been known from the earliest times. We have clear evidences that it was described by Gabucinus in the year 1547, and also subsequently by Cornelius Gemma, who, in a work published some thirty years later, refers to an epizootic disease prevalent in Holland during the year 1552, and which was very justly attributed to the parasite in question. After this date many writers described the liver fluke more or less accurately, and entire volumes were devoted to the consideration of the formidable disease which it occasions. The nomenclature of the parasite has been a subject of controversy. Amongst naturalists in general the common liver fluke is often described under the combined generic and specific name of

Distoma hepaticum; but the title is both incorrect and inappropriate. The proper generic appellation of this parasite is *Fasciola*, as first proposed by the illustrious Linneus (1767) and subsequently adopted by F. Müller (1787), Brera (1811), Ramdohr (1814), and others. Unfortunately Retzius (1786) and Zeder (1800) changed the generic title without good cause, and the majority of writers, following their authority, refused to employ the original name, although a consideration of the distinctive types of structure severally displayed by the genera *Distoma* and *Fasciola* fairly demanded the retention of the Linnean title. In later times M. Blanchard (1847) strongly advocated the original nomenclature, and I have myself continually urged its adoption. On somewhat different grounds Professor Moquin-Tandon followed the same course.

In the sexually mature state the liver fluke commonly measures three fourths of an inch in length, occasionally reaching an entire inch or even sixteen lines; its greatest breadth also varying from half an inch to seven or eight lines transversely; body very flat, presenting distinct dorsal and ventral surfaces, frequently curled toward the latter during life; upper or anterior end suddenly constricted, produced and pointed in the centre, forming the so-called head and neck; posterior extremity less acuminated, sometimes rounded, or even slightly truncated; margins smooth, occasionally a little undulated, especially towards the upper part; oral sucker terminal, oval, rather smaller than the ventral acetabulum, which is placed immediately below the root of the neck; reproductive orifices in the middle line, a little below the oral sucker; intromittent organ usually protruded and spirally curved; a central, light-coloured space, covering two thirds of the body from above downwards, marks the region of the internal male reproductive organs, being bordered on either side and below by a continuous dark band, indicating the position of the so-called yelk-forming organs; a small, brown-coloured, rosette-like body situated directly below the ventral acetabulum, marks the limits of the uterine duct; a series of dark lines, branching downwards and outwards on either side, indicate the position of the digestive organs; general color of the body pale brownish yellow, with a slight rose tint. The surface of the body, though smooth to the naked eye, is clothed throughout with small epidermal spines which diminish in size towards the tail.

If any argument were necessary to show how desirable it is

to furnish full descriptions of the commoner kinds of parasite, I could adduce numerous instances that have been brought under my notice where professional men and others have been entirely mistaken as to the essential nature of their parasitic finds. Thus, I have known an instance where a great authority on the diseases of dogs has persisted in asserting for the free proglottides of a tapeworm a nematode origin; and, in like manner, human tapeworm-segments have frequently been mistaken for independent fluke parasites. One of the most remarkable instances of this kind is that which I have elsewhere described as an error on the part of Dr Chabert. My reasons for so regarding his interpretation of the facts observed by him stand as follows:

In the 'Boston Medical and Surgical Journal' for the years 1852-53-54, Dr J. X. Chabert described several cases of Tænia, and he averred that the tapeworms were associated with numerous specimens of *Distoma hepaticum*. The passage of distomes by patients during life was even regarded by Dr Chabert as indicative of the presence of Tænia within the intestines. Surely, I remarked, Dr Chabert was mistaken. Are not these so-called distomes the well-known *proglottides?* Not willingly doubting Dr Chabert's statements, but desirous, if possible, of verifying the accuracy of his conclusions, I wrote to him (March 22nd, 1864) requesting the loan of a specimen, but I was not fortunate enough to receive a reply. In the "Case of Tænia" in a boy four and a half years old, given in the 49th vol. of the journal, Dr Chabert writes as follows:—"In consequence of his passing the *Distoma hepaticum*, I concluded he must be afflicted with Tænia." Further on it is added, that the administration of an astringent injection "caused the discharge of innumerable small worms (*Distoma hepaticum*)." I think this is quite decisive. The idea of "innumerable" flukes being expelled in this way is altogether out of the question.

The only genuine case in which any considerable number of Distomata, of this species, have been observed in the human subject is the one recently recorded by Dr Prunac. In this instance two flukes were vomited along with blood immediately after the administration of salines (sel de Seignette), and about thirty were passed per anum. On the following day, some tapeworm proglottides having been evacuated, both salts and male-fern extract were administered. This caused the expulsion of an entire tapeworm, and also about twenty more flukes. Not-

withstanding this successful treatment the hæmatemesis returned in about a month, when, finally, three more flukes were vomited and the bleeding ceased. Had not the parasites been submitted for identification to a competent observer (Prof. Martins, of Montpellier), some doubt might have been entertained as to the genuineness of this remarkable case. In reference to Dr Prunac's comments on the facts of fluke-parasitism in man, I will only remark that Dr Kerr's Chinese cases, to which he refers, were probably due to *Distoma crassum* and not to *D. hepaticum.* The Chinese flukes will be noticed below.

BIBLIOGRAPHY (No. 3).—Full references to details of the cases by Partridge, Fox, and Harris are given in Appendix B. to Lankester's Edit. of *Küchenmeister's* Manual. See also the works of *Davaine* and *Leuckart* (*l. c.* Bibl. No. 1).—*Carter, H. V.*, "Note on *Distoma hepaticum*" (from a patient under the care of Mr Pandoorung), 'Bombay Med. and Physical Soc. Trans.' (Appendix), 1862.—*Chabert, J. X.* (quoted above). *Murchison, C.*, 'Clinical Lectures on Diseases of the Liver, (2nd Edit., Appendix), London, 1877.—*Prunac*, De la Douve ou Distome hépatique chez l'homme; in 'Gazette des Hôpitaux' for December, 1878 (p. 1147). For further references in this work, see Bibliog. No. 49.

Distoma lanceolatum, Mehlis.—At least three instances of the occurrence of this small fluke in the human body have been observed. The authority for these cases rests, severally, with Bucholz, who found them in the gall bladder in considerable numbers at Weimar; with Chabert, who expelled a large number from the intestines of a girl in France; and with Küchner, who obtained forty-seven specimens from a girl in Bohemia. Probably many similar instances have been overlooked, and Küchenmeister hints that Duval's parasites (above mentioned) may have been this species. Although this worm will again be incidentally noticed in connection with bovine parasites (and its ciliated larvæ will also be referred to when discussing the characters of the embryo of Bilharzia), I here subjoin a diagnosis of the characters of the adult parasite. The lancet-shaped liver fluke is a small flat helminth, measuring rather more than the third of an inch in length, and about one line and a half in breadth, being also especially characterised by its lanceolate form; the widest part of the body corresponds with a transverse line drawn across the spot where the vitellaria terminate below, and from this point, on

either side, the width of the animal becomes gradually narrowed towards the extremities; both ends are pointed, but the inferior or caudal one more obtusely than the anterior or oral end; the general surface is smooth throughout, and unarmed; the reproductive orifices are placed in the central line immediately in front of the ventral sucker, and below the point at which the intestine bifurcates; the oral sucker is nearly terminal, and $\frac{1}{50}''$ in breadth, the ventral acetabulum being about the same diameter; the testes form two lobed organs placed one in front of the other in the middle line of the body and directly below the ventral sucker; the uterine canal is remarkably long, forming a series of tolerably regular folds, which occupy the central and hinder parts of the body, reaching almost to the caudal extremity. The vitelligene glands cover a limited space, on either side of the centre of the body near the margin. The *foramen caudale* communicates with a contractile vesicle, which passes upwards in the form of a central trunk-vessel, early dividing into two main branches; these latter reach as far forwards as the œsophageal bulb, opposite which organ they suddenly curve upon themselves, retracing their course for a considerable distance backwards; the digestive canals are slightly widened towards their lower ends, which occupy a line nearly corresponding with the commencement of the lower fifth of the body; the ova are conspicuous within the uterine folds, which present a dark brownish color in front, passing to a pale yellow color below.

FIG. 1.—The lancet-shaped fluke (*Distoma lanceolatum*), showing the disposition of the digestive and reproductive organs internally. Viewed from behind; mag. about 12 diameters. After Blanchard.

In reference to Kichner's remarkable case I reproduce an abstract of it from Leuckart's account ('Die menschlichen Parasiten,' Bd. i, s. 608), the original particulars of which were communicated to Leuckart by Dr Kichner himself:—

"Dr Kichner's patient was a young girl, the daughter of the parish shepherd at Kaplitz, having been accustomed to look after the sheep ever since she was nine years old. The pasture where the animals fed was enclosed by woods, being traversed by two water dykes, and being, moreover, also supplied by ten little stagnant pools. These reservoirs harboured numerous amphibia and mollusks (such as *Lymnæus* and *Paludina*), and the child often quenched her thirst from the half putrid water. Probably she also partook of the watercresses growing in the ditches. At length her abdomen became much distended, the limbs much emaciated, and her strength declined. Half a year before death she was confined to her bed, being all the while shamefully maltreated by her step-mother. Dr Kichner only saw her three days before her death, and ascertained that she had complained of pain (for several years) over the region of the liver. A *sectio cadaveris* was ordered by the Government, when (in addition to the external evidences of the cruel violence to which the poor creature had been subjected) it was found that she had an enormously enlarged liver, weighing eleven pounds. The gall-bladder which was very much contracted and nearly empty, contained eight calculi and forty-seven specimens of the *Distoma lanceolatum*, all of which were sexually mature."

As I have remarked in a former comment on this singular case, one can have no difficulty in arriving at the conclusion that these parasites were obtained from the girl's swallowing trematode larvæ, either in their free or in their encysted condition. Leuckart says it was not possible to ascertain whether the parasites had any connection with the gall-stones, or whether the two maladies, so to speak, were independent of each other; yet this question might possibly have been solved if the calculi had been broken up in order to ascertain their structure. It is just possible that dead distomes may have formed their nuclei, and if so, the circumstance would, of course, point to the worms as the original source of the malady.

So far as I am aware, the actual transformations undergone by the larvæ of *Distoma lanceolatum* have not been observed. The *Planorbis marginatus* has been confidently referred to as the intermediate bearer of the cercariæ of the common fluke, and Leuckart supposes that the same mollusk harbours the larvæ of this species. The ciliated embryos carry a boring

spine or tooth, and it is most probable that the higher larvæ are similarly armed.

Bibliography (No. 4).—*Kichner* (see *Leuckart*), quoted above.—*Cobbold*, 'Entozoa' (p. 187).—The case by Bucholz (reported as one of *Fasciola hepatica*) is given by *Jördens* in his work (quoted by Diesing and Leuckart) 'Entomologie und Helminthologie des menschlichen Körpers' (s. 64, tab. vii, fig. 14), 1802.—*Chabert's* French case is quoted by *Rudolphi* in his 'Entozoorum sive vermium,' &c. (*loc. cit.*, Bibl. No. 1), p. 326, 1808.

Distoma crassum, Busk.—This large species was originally discovered by Prof. Busk in the duodenum of a Lascar who died at the Seamen's Hospital, 1843. It, however, remained undescribed until 1859, when, with the discoverer's approval, I gave some account of it to the Linnean Society.

Of the fourteen original specimens found by Mr Busk, several have been lost. The one that he himself gave me I handed over to Prof. Leuckart, and it is figured in his work ('Die mensch. Par.,' s. 586). A second is preserved in the museum attached to the Middlesex Hospital, and a third is contained in the Museum of the Royal College of Surgeons. This last-named specimen is the best of the original set. It supplied me with the few details of structure figured in outline in my 'Introductory Treatise' (fig. 42, p. 123), published in 1864; and it also in part formed the basis of the description of the species communicated to the Linnean Society in June, 1859 ("Synopsis of the Distomidæ," p. 5, 'Proceedings,' vol. v). The late Dr Lankester, it is true, was the first to give a distinctive title to this entozoon (*Distoma Buskii*); but as the discoverer objected to this nomenclature, and as Dr Lankester's proposed terms were unaccompanied by any original description, I requested Mr Busk to suggest a new name for the worm, which he accordingly did. As I subsequently pointed out, Von Siebold had already employed the compound title *Distoma crassum* to designate a small fluke infesting the house-martin (*Hirundo urbica*); but for reasons similar to those which contributed to set aside Dr Lankester's nomenclature, the title adopted in my synopsis at length came to be recognised by Leuckart and by other well-known helminthologists. Before this recognition took place, Dr Weinland, of Frankfort, had so far accepted Lankester's nomenclature as to call the species *Dicrocœlium Buskii*. In my judgment there are no sufficient grounds for retaining Dujardin's genus. Further, I may

observe that, in addition to the above-mentioned specimens, two others are preserved in the Museum at King's College. Thus, only five out of the fourteen specimens are still in existence.

No well-authenticated second instance of the occurrence of this worm took place until the year 1873, when a missionary and his wife from China consulted Dr George Johnson respecting parasites from which they were suffering. After a brief interval, both of Dr Johnson's patients were by an act of courtesy on the part of this eminent physician placed under my professional care. I need hardly add that Dr Johnson had from the very first recognised the trematode character of the parasites. From the patients themselves I ascertained that they had been resident in China for about four years. During that period they had together freely partaken of fresh vegetables in the form of salad, and also occasionally of oysters, but more particularly of fish, which, in common with the oysters, abound in the neighbourhood of Ningpo. From their statements it appeared to me that to one or other of these sources we must look for an explanation of the fact of their concurrent infection. Fluke larvæ, as we know, abound in mollusks and fish; but whether any of the forms hitherto found in oysters or in fish have any genetic relation to the flukes of man, is a question that cannot very well be settled in the absence of direct experimental proof. I should add that it was not until after their visit to the interior of the country, some 130 miles distant from Ningpo, that the symptoms (which Dr Johnson in the first instance, and myself subsequently, considered to have been due to the presence of the parasites) made their appearance. Whilst in the country the missionary and his wife freely partook of freshwater fish, and on one occasion they received a quantity of oysters that had been sent up from Ningpo. The husband assured me that the fish were always thoroughly well cooked.

If it be asked what were the symptoms produced, I can only furnish such few and hitherto unpublished particulars as the missionary himself supplied. I need hardly say that he was a highly cultured and intelligent gentleman, since only such persons are chosen for missionary work in China.

From inquiries made by me on the 29th of January, 1875, I learnt that they left Ningpo in November, 1872, and travelled thence 130 miles into the interior of the country. In the following September, or about ten months subsequently, the missionary was attacked with diarrhœa, which persisted until

expulsion of some of the parasites had occurred. According to the patient's statements this result, so far, was entirely due to his having been placed on a milk diet; this course of treatment having been recommended by Dr Henderson, of Shanghae. The patient himself always suspected the presence of intestinal worms of some sort or other, although a Japanese doctor laughed at the idea of such a thing. Some other doctor treated this missionary for parasites, administering both male-fern and santonine without effect.

It was not until several months had elapsed that his wife was attacked with diarrhœa. In both cases there was more or less flatus. The motions were white, and there were other indications implying that the liver was affected. Later on, symptoms of indigestion, with heartburn, set in and became very severe. Streaks of blood appeared in the fæces, but there was no dysentery. For the most part these symptoms were attributed to the effects of climate.

When, in the month of February, 1875, I saw the missionary a second time, professionally, I found that all the old symptoms had returned. He had a foul tongue, the surface of the body was cold, he felt chills, and the pulse, though regular, registered ninety-six to the minute. Indigestion, nausea, headache, and diarrhœa had reappeared. Notwithstanding these febrile symptoms, so satisfied was the patient himself that all his ailments were entirely due to the presence of parasites, that I felt inclined to take the same view of his case. Accordingly my attention was principally directed to an effort for their expulsion; and in this view I ordered an aloetic pill followed by a castor-oil emulsion. This having no effect, I subsequently prescribed aloes and assafœtida pills, followed by scammony mixture. The action of the latter drug did not occasion griping, but, although efficient, led only to negative results. I should mention that in the patient's judgment none of the vermifuges administered to him at any time had exerted any influence in the expulsion of the flukes. He was still thoroughly impressed with the notion that the milk diet, ordered by Dr Henderson, was the sole cause of their expulsion.

As even a missionary could not live by milk alone I insisted upon a more substantial diet. The milk, indeed, had occasionally been supplemented by Liebig's extract of meat and by light farinaceous food. When I last saw him neither he nor his wife had passed any more flukes, but they did not feel satisfied that no

more guests remained. Somewhat improved in general health, the missionary resolved to go back to his duties in China. I expressed my fears, however, that his strength would prove unequal to the work.

From the size and almost leathery texture of the two flukes which were in the first instance submitted to my notice, I at once recognised the species; but as they were spirit-specimens, I requested that if any more examples were obtained they should be sent to me in the fresh state. Fortunately others were brought in a few days, when, from an examination conducted whilst they were still fresh, I was able to make out several details of structure which had hitherto escaped notice. Altogether I secured seven specimens, three of them being in a mutilated condition. In what way these mutilations (as shown by my dried specimens) occurred I have not been able to make out, either by personal observation or by questioning the bearers. Two of the parasites look as though portions had been carefully excised near the centre. The new facts I have gleaned were derived from the examination of two comparatively small specimens, one of which, dried, has, by Prof. Rolleston's desire, been deposited in the anatomical department of the University Museum at Oxford. When I took occasion to bring some of the new specimens under Mr Busk's attention, he at once recognised them as referable to the species he had long ago discovered.

The earliest literary notice of *Distoma crassum* appeared in Dr Budd's classical treatise 'On Diseases of the Liver;' and in it the author correctly stated, from data supplied by Mr Busk, that these human flukes were "much thicker and larger than those of the sheep," being, it is added, from "an inch and a half to near three inches in length." The longest of my recent specimens, however, scarcely exceeds two inches, whilst the smallest and most perfect (the one at Oxford) measures less than an inch from head to tail. The greatest width of my broadest specimen is little more than half an inch, or $\frac{9}{16}''$. None of the twelve examples that I have examined approach the length of three inches; but Mr Busk assured me that, judging from his recollection, some of his specimens were even longer than that. I fear, nevertheless, that the estimate given in my Synopsis is somewhat exaggerated; at all events it is so for average specimens.

The new anatomical facts made out by me bear reference

principally to the reproductive apparatus. What else I have observed is for the most part confirmatory of the statements made by Mr Busk. In particular, his brief account of the position and character of the digestive organs was not only confirmed by my earlier examinations, but is now re-verified. In the representation given in my 'Introduction' I showed in dotted outline two large organs which I supposed to be the testes. I distinctly observed radiating lines proceeding from the centre in each; but I could not discover the slightest trace of any limiting border to either organ. I now found in the same position two nearly circular flattened masses with clearly defined limits (*i*, *k*). No doubt could be entertained as to the testicular character of the lower organ (*k*). In the original drawing I further indicated the presence of a third and much smaller globular mass, which I termed the ovary; but what I supposed to represent this organ in the particular specimen from which the accompanying illustration was drawn turns out to be merely a hernial protrusion resulting from injury (*h*). The radiating, broad, and branching seminal ducts are beautifully distinct in one of my specimens, forming the most attrac-

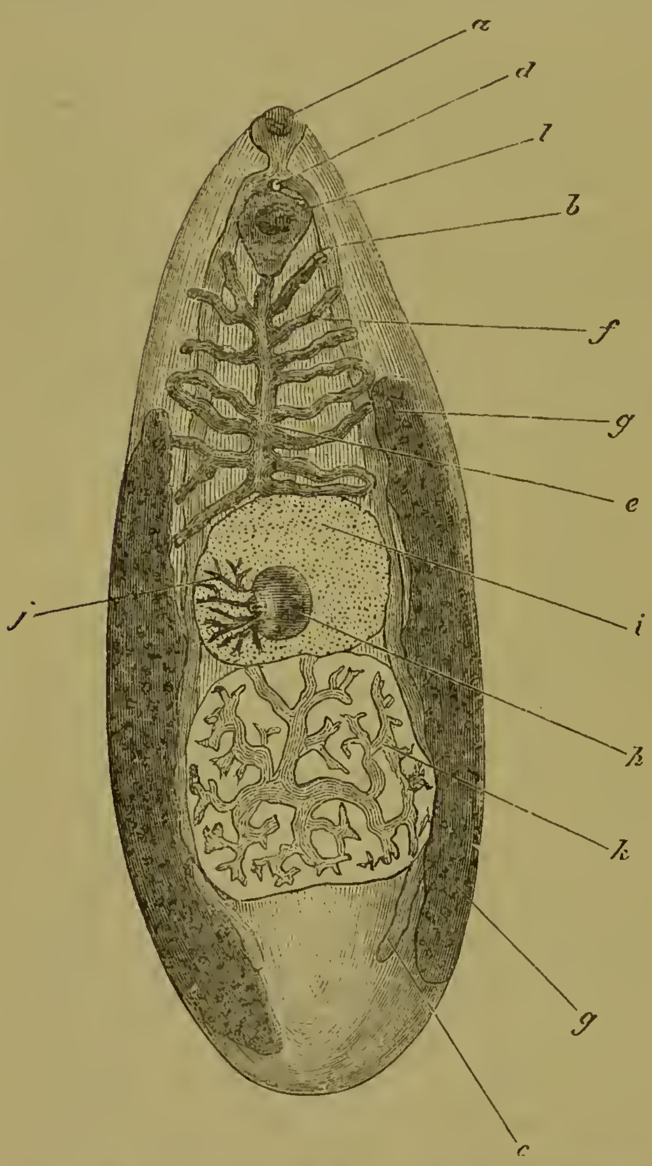

Fig. 2.—The large human fluke (*Distoma crassum*). *a*, Oral sucker; *b*, intestine; *c*, cæcal end of same; *d*, reproductive papilla; *e*, uterine rosette (the folds of which are not branched); *f*, one of the folds (in profile); *g*, vitellarium; *h*, hernial protrusion (the result of an injury to the specimen); *i*, upper testis; *j*, streaks or layers of seminal fluid which have escaped by rupture and assumed a branched appearance; *k*, lower testis uninjured (but slightly altered in outline from flattening); *l*, ventral sucker. Magnified 2 diameters. Original.

tive feature of the parasite's organisation (*k*). In consequence of injury to the specimen which is here drawn, the upper testis (*i*) displays no seminal tubes. I made out the female reproductive organs with more completeness. In the outline drawing given in my introductory treatise I had indicated the probable position of the uterine folds; reducing the organ to the simplest expression of what I concluded must obtain in the normal condition. My conjecture was perfectly correct. The uterus consists of irregularly folded tubes, which, though here and there apparently branching from a central tube, are in reality folded evenly upon themselves. The oviduct can be distinctly traced to its outlet in the reproductive papilla, which, as usual in true Distomes, is placed in the middle line, immediately above the ventral sucker. In my examination of Mr Busk's original specimens I could not find the slightest trace of vitelligene organs; but in my fresh examples I not only obtained proof that these organs were largely developed, but that their limitations could be fixed with accuracy (*g g*). They consisted of two large elongated masses, one on either side of the body, occupying about two thirds of the entire length of the parasite. Their yolk-vesicles were distinctly seen; but the main efferent canals were only here and there traceable. Clearly, the position and character of the yolk-forming glands of this large human fluke are quite unlike those of any of its congeners. This fluke is a remarkably fine species, and, when viewed in the fresh state with a powerful pocket-lens, presents a most striking appearance. I did not observe any cutaneous spines. I found the eggs to present an average long diameter of about $\frac{1}{200}''$, by $\frac{1}{330}''$ in breadth. They are therefore somewhat smaller than those of the common fluke. In the specimen preserved in the Hunterian Museum there was complete evidence of the presence of an excretory outlet at the caudal extremity; but I did not succeed in finding any trace of the water-vascular system higher up. I have no doubt, however, that it exists.

As regards the affinities of *Distoma crassum*, it is clear that this Trematode has little in common either with the liver-fluke of cattle and sheep (*Fasciola hepatica*), or the still larger species obtained by me from the giraffe (*Fasciola gigantea*). The simple character of the digestive tubes obviously connects it more closely with the lancet-shaped fluke (*Distoma lanceolatum*), the last-named parasite being, as already shown, an occasional

resident in the human liver, where its presence, moreover, undoubtedly contributed towards the production of the fatal result.

In my remarks on the missionary's diet it is hinted that the Ningpo oysters may have played the *rôle* of intermediary bearers to the parasite in question; and as tending in some measure to strengthen this notion, it should be borne in mind that Mr Busk's original fluke-bearer came from the east. It is not improbable that the Lascar host may have partaken of the same particular species of fish or shell-fish that the missionary and his wife partook of. Be that as it may, the frequency of the occurrence of Trematodes and their larvæ in marine mollusks is well known. According to Woodward, several species of oyster are sold in the Indian and Chinese markets. Thus, it would require the skill of a malacologist to determine the particular species of *Ostrea* to which the Ningpo oysters should be referred.

Mons. Giard is of opinion that the singular larvæ known as *Bucephali* attain sexual maturity in sharks and dog-fishes; therefore it is extremely unlikely that the *Bucephali* should have been in any way concerned in the infection of our missionary and his wife; nevertheless there remains the probability that these human bearers swallowed other kinds of Trematode larvæ when they consumed the Ningpo oysters. Moreover, if it should happen that none of the other larvæ occurring in oysters are capable of developing into flukes in the human territory, it yet remains highly probable that some one or other of the various encysted (and therefore sexually immature) Trematodes known to infest marine fishes will turn out to be the representative of our *Distoma crassum*. In this connection we must not forget that the flesh of the *Salmonidæ* forms the probable source of human *Bothriocephali;* and there is some likelihood that salt-water fishes, if not actually the primary, may become (after the manner explained by M. Giard) the secondary intermediary bearers of fluke-larvæ. At all events, I am inclined to look to the Ningpo oysters, or to some other of the various species of marine shell-fish sold in eastern markets, as the direct source of *Distoma crassum;* for, in addition to the bucephaloid cercarians, we have abundant evidence of the existence of other and more highly developed fluke-larvæ in marine bivalve mollusks.

In this connection I will only further observe that we possess

very little knowledge of the parasites which take up their abode in the viscera of savages. This ignorance results partly from the fact that these untutored races, as proved by the statements of Kaschin and others, actually, in the matter of severe symptoms, suffer much less from the presence of intestinal worms than their civilised fellow-men do. The subject is worthy of further attention, but no one, so far as I am aware, has cared to institute the necessary inquiries in a methodical way. I strongly suspect that several of the human parasites which we now consider to be rare would be found to be abundant if by means of post-mortem examinations and other methods of investigation we could be made acquainted with the facts of helminthism as they occur amongst the raw-flesh and fish-eating savage tribes. Of course any person, notwithstanding the utmost care and cleanliness, as in the cases before us, may contract a noxious parasite; nevertheless, speaking generally, it may be said that the measure of internal parasitism affecting any given class of people bears a strict relation to the degree of barbarism shown by such persons in their choice of food and drink, and in their manner of eating and drinking. This statement, if true, is not destitute of sanitary importance; moreover, it applies not alone to ourselves, but also to all the domesticated animals that serve our wants. Cleanliness is just as necessary for their welfare as for our own.

In the spring of 1878 my patients returned from China. They had experienced fresh attacks from the parasite; moreover, one of their children, a little girl, was also victimised by the same species of fluke. Thus, in one family I have encountered three cases of fluke-helminthiasis due to *Distoma crassum!* One of the worms passed by the little girl *per anum* is now in my possession. It not only shows the upper testis perfectly, but also the many times transversely folded, simple, uterine rosette which is certainly not branched. There are also traces of an organ which I take to be the cirrhus-pouch; but I have never seen the penis protruded externally.

For the purposes of diagnosis I subjoin the following characters. The *Distoma crassum* is a large, flat helminth varying from an inch and a half to two and a half inches in length, and having an average breadth of five eighths of an inch; it is especially also characterised by its uniform and considerable thickness, combined with the presence of a double alimentary canal which is not branched; the body is pointed in front, and

obtusely rounded posteriorly; the integument being smooth and unarmed; the reproductive orifices placed immediately above the ventral sucker; the testes form two large rounded organs, situated below the uterine rosette, and disposed in the middle line, one in front of the other; the uterine folds occupy the front part of the body; near the lateral margins there are two large vitelligene glands, one on either side of the intestinal tube; the excretory organ probably consists of a central trunk with diverging branches, opening below.

Bibliography (No. 5).—*Budd*, original notice in his 'Diseases of the Liver,' 2nd edition, quoted by Lankester in Appendix B to Küchenmeister's 'Manual of Parasites,' p. 437, 1857. —*Cobbold, T. S.*, "Synopsis of the *Distomidæ*," in 'Journ. of the Proceed. of the Linnean Soc.,' vol. v, Zool. Div., 1860 (original description p. 5).—*Idem*, 'Entozoa,' p. 193, 1864.—*Idem*, "Remarks on the Human Fluke Fauna, with especial reference to recent additions from India and the East," the 'Veterinarian,' April, 1876.—*Idem*, "On the supposed Rarity, Nomenclature, Structure, Affinities, and Source of the large Human Fluke (*D. crassum*)," 'Linn. Soc. Journ.,' vol. xii, Zool. Div., 1876, p. 285 *et seq.*—*Idem*, "Observations on the large Human Fluke, with notes of two cases in which a missionary and his wife were the victims," the 'Veterinarian,' Feb., 1876.—*Idem*, "The new Human Fluke," in a letter published in the 'Lancet,' Sept., 1875.—*Leidy*, in 'Proceed. Acad. Nat. Sciences of Philadelphia;' see also Dr McConnell's paper quoted below (Bibl. No. 6).—*Leuckart*, l. c., Bd. I, s. 560. —*Weinland*, l. c. (Bibl. No. 2), Appendix, p. 87.

Distoma Sinense, Cobbold.—The discovery of this species is due to Prof. J. F. P. McConnell, who "on the 9th of Sept., 1874, found a large number of flukes in the liver of a Chinese, obstructing the bile ducts." The species measures $\frac{7}{10}''$ in length, by $\frac{1}{7}''$ in breadth, the eggs being $\frac{1}{833}''$ by $\frac{1}{1666}''$. Dr McConnell showed in his original memoir that the worm cannot well be confounded with *Fasciola hepatica*, with *Distoma lanceolatum*, or with *D. conjunctum*. In this conclusion he was supported by Dr. T. R. Lewis, who examined the specimens with him. In a letter communicated to the 'Lancet,' quoted above, I proposed the nomenclature here given; but Prof. Leuckart, unaware of this step, afterwards suggested the terms *Distomum spatulatum*. Later on I received numerous specimens from Calcutta, the examination of which enabled me to confirm the

accuracy of the original description. As regards the male organs in the subjoined figure, it will be seen, by comparing the lettering and references, that I have interpreted the facts of structure somewhat differently from Prof. McConnell.

In the month of December, 1874, a Chinese died in the Civil Hospital at Port Louis, Mauritius, whilst he was under the care of Dr William Macgregor, chief medical officer of the Colony of Fiji. The post mortem revealed the presence of a very great number of flukes in the bile-ducts. Dr Macgregor described these parasites with great care, and having favored me with a copy of his manuscript I at once recognised the worms to be identical with the species discovered by McConnell. I also received through Dr Henry Clark, of Glasgow, two Mauritius specimens, which when compared with the Calcutta examples proved to be specifically identical. Dr Macgregor's paper, communicated to the Glasgow Medico-Chirurgical Society, gives full particulars of the helminthiasis associated with this parasite, whilst both his and Prof. McConnell's account of the structure of the worm are remarkably complete in details, and well illustrated. It is not a little curious to notice that although these parasites were obtained in countries far removed from China, they were in both instances taken from Chinese; moreover, from the statements of Macgregor, it appears very probable that the parasites in question are a common source of liver disease. Without doubt oriental habits are eminently favorable to fluke infection, for we are now acquainted with four species of flukes whose geographical range is limited to eastern parts.

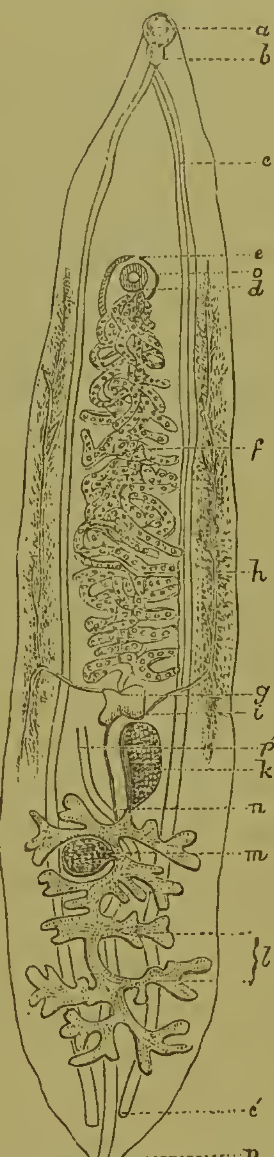

FIG. 3.—The Chinese fluke (*Distoma Sinense*). *a*, Oral sucker; *b*, œsophageal bulb; *c*, intestine; *c′*, cæcal end; *d*, ventral sucker; *e*, genital pore; *f*, uterine folds; *g*, ovary; *h*, vitellarium; *i*, vitelligene duct; *k*, upper seminal reservoir; *l*, testes; *m*, lower seminal pouch; *o*, vas deferens; *p*, pulsatile vesicle; *p′*, water vessel. After McConnell.

BIBLIOGRAPHY (No. 6).—*McConnell, J. F. P.*, "Remarks on the Anatomy and Pathological relations of a new species of

Liver-fluke," 'Lancet,' Aug. 1875; repr. in the 'Veterinarian,' Oct., 1875; also in the 'Lancet,' March 16th, 1878, p. 406.—*Macgregor, W.*, "A new form of Paralytic Disease, associated with the presence of a new species of Liver Parasite (*Distoma Sinense*)," 'Glasgow Med. Journ.' for Jan., 1877; also in the 'Lancet' for May 26th, 1877, p. 775.—*Cobbold, T. S.*, in a note to the 'Lancet,' Sept., 1875, and in the Appendix to Macgregor's paper, p. 15, 1877.—*Leuckart, R.*, l. c., Bd. ii, s. 871, 1876.

Distoma conjunctum, Cobbold.—The little fluke which I first discovered in the gall-ducts of an American fox (*Canis fulvus*) was fourteen years afterwards obtained from pariah dogs in India by Dr. T. R. Lewis (1872); but it remained for Prof. McConnell to show that this entozoon also invades the human subject (1874). A second instance of its occurrence in man was recorded in 1876. We all figured the worm, and in respect of general details our descriptions for the most part agreed (fig. 56). The worms from the dog and fox gave an average of $\frac{1}{4}''$ in length, but the majority of those found by McConnell in man were fully $\frac{3}{8}''$ from head to tail.

Writing in the spring of 1876 Dr McConnell says:—"In the 'Lancet' for the 21st of August, 1875, I published the description of a new species of liver-fluke found in the bile-ducts of a Chinaman (*sic*) who died in this hospital. Dr Spencer Cobbold has very kindly interested himself in this discovery, and proposed the name of *Distoma Sinense* for the new fluke. This discovery (in September, 1874) has stimulated me to pay still greater attention to the morbid conditions of the biliary canals in our post-mortem examinations; but, although more than 500 autopsies have been conducted since that date, I have not met with another instance of distomata in the liver until within the last fortnight. On the 9th of January, 1876, in examining the liver of a native patient who had died in the hospital, I again found a large number of flukes in the bile-ducts, and having carefully examined many specimens, I recognise the species as the *D. conjunctum* of Cobbold. Dr Cobbold discovered this fluke in 1858; but, as far as I am aware, the human liver has never hitherto been found infested by these parasites, and this will give general interest and importance to the following case."

"Jamalli Khan, a Mahommedan, aged twenty-four, admitted into the hospital on the 25th of December, 1875. He is a resident of Calcutta, and an ordinary labourer (coolie). He

states that he had been suffering from 'fever' for the last two months, at first intermittent in character, but for the last seven days more or less continued. He is much emaciated and reduced in strength. Complains of pain on pressure over the liver and spleen; the latter can be felt much enlarged, reaching downwards to nearly the level of the umbilicus; the lower border of the liver, however, can only just be felt below the ribs. Temperature on evening of admission 101° F. Conjunctivæ are anæmic, but not jaundiced. Has also a little bronchitis. The fever continued with slight remissions for ten days (January 4th, 1876), the highest diurnal temperature (in the afternoon) varying from 103° to 104° F.; it then abated, but dysentery set in. He began to pass six or eight stools in the twenty-four hours, attended with much griping, and containing varying quantities of blood-tinged, gelatinous mucus. These became more frequent, in spite of treatment, during the next three days, and on the 8th of January he was manifestly sinking; passed his evacuations into the bedclothes, became cold and collapsed, and died in this state that same evening.

"A post-mortem examination was made on the following morning, thirteen hours after death. All the organs of the body were found more or less anæmic, but exhibited nothing remarkable with the following exceptions. The lungs towards their posterior margins and bases were dark, but still spongy and crepitant. The spleen was found greatly enlarged, heavy; capsule tense and stretched; substance soft, reddish brown, irregularly pigmented; weight 1 lb. 13 oz. The liver was of about normal size; its surfaces smooth, the capsule slightly hazy looking. Hepatic substance firm, but abnormally dark, and the bile-ducts particularly prominent and thickened. Numbers of small distomata escaped from the incisions made into the organ, and could be seen protruding from the dilated biliary canals. The gall-bladder was filled with thick greenish-yellow bile, measuring about an ounce and a half, but containing no parasites, and no ova even could be detected on microscopical examination of this bile and of scrapings from the lining membrane of the gall-bladder. The cystic duct was free from obstruction. The condition of the common choledic duct could not so well be ascertained, as the liver had been removed from the abdominal cavity before anything extraordinary had been detected in its condition, but, so far as it could be examined, it was found patent; the duodenal mucous

membrane was well bile-stained, and there was evidence of biliary colouring matter in the fæcal contents of the bowels. On carefully dissecting out, and then laying open, the biliary ducts in a portion of the right lobe of the liver (the rest being preserved entire), numbers of distomata were found within them, lying singly, flattened, and generally with the anterior extremity, or "oral sucker," directed towards the periphery of the organ, the posterior extremity towards its centre; or in twos, threes, or even little groups of fours, variously coiled upon themselves or upon each other. The lining membrane of the biliary canals was found abnormally vascular, its epithelial contents abundant (catarrh ?), and, among these, ova could be detected under the microscope. Sections of the liver, hardened and then examined in glycerine, showed fatty infiltration of the lobular structure, but not to any advanced degree; the bile ducts considerably dilated, their walls thick and hypertrophied, but nothing else abnormal, or in any way remarkable. The weight of the liver was 3 lbs. In the transverse and descending colon numerous indolent-looking, shallow, pigmented ulcers were found, and in the rectum others evidently more recent and highly injected. The submucous tissues throughout were abnormally thickened. The intestinal contents consisted of only about three ounces of thin yellowish (bilious) fæcal fluid, with small bits of opaque mucus. This was carefully washed and examined, but no flukes were discovered. About a dozen distomata escaped from the liver on making the primary incisions, and quite twice this number was found subsequently within the biliary canals. Only a portion of the right lobe has, as I have said, been dissected, so that it may be confidently stated that probably not less than a hundred of these flukes must have infested this liver. All were found dead, but it must be remembered that the autopsy was performed thirteen hours after the death of the patient. It is remarkable that in this case, as in the one before described by me, no distomata were found in the gall-bladder. The presence of these parasites in the bile-ducts seems to have led to catarrhal inflammation of their lining membrane and abnormal thickening and dilatation of their walls, but there is no evidence of their having caused sufficient obstruction to produce cholæmia, as in the case just referred to, and no marked pathological change could be detected in the lobular structure of the liver."

After referring to the anatomical descriptions of the worm, as recorded by myself (in 'Entozoa') and by Lewis (in the

memoir quoted below), Professor McConnell further observes that the addition of a few more particulars seems necessary for the determination of the identity of the species. He then gives the following characters :

" Body lanceolate, anterior and posterior extremities pointed, the latter obtusely. Surface covered with minute spines or hairs. Average length $\frac{3}{8}''$ (three eighths of an inch); average breadth $\frac{1}{10}''$. 'Ventral' sucker slightly smaller than 'oral.' Reproductive papilla or genital orifice placed a little above and to one side of the former. Alimentary canal double and unbranched. Uterine folds and ovary placed in the median line, and above the male generative organs, the latter consisting of two very distinct globular bodies or testes. Ova of the usual type, *i. e.* oval in outline, having a double contour, and granular contents ; average length $\frac{1}{750}''$; average breadth $\frac{1}{1333}''$. The only point of note is that the average length of these flukes is greater than that of the same species found by the authors above referred to. The *D. conjunctum* in the American fox, and in the pariah dog, has an average length of $\frac{1}{4}''$; only two or three specimens of this size were found in this liver, and these showed evidences of immaturity; a few were also found $\frac{1}{2}''$ in length; but the great majority exactly $\frac{3}{8}''$. The anatomical characters are otherwise precisely identical."

Professor McConnell concludes his communication by a remark in reference to the common source of infection shared by mankind and dogs in India. The occurrence, however, of this entozoon in an American red fox points to a very wide geographical distribution of the species. It is hardly likely that the fox, though dying in the London Zoological Society's Menagerie, should have contracted the parasite in England. In the second half of this work I shall reproduce my original drawing (fig. 56) from the 'Linnean Transactions;' but I may refer to my Manual (quoted below) for a reproduction of McConnell's figure. In my original specimens the integumentary spines had fallen, probably as a result of post-mortem decomposition.

Bibliography (No. 7).—*Cobbold, T. S.*, " Synopsis of the Distomidæ " (l. c.), 1859; and in "Further Observations on Entozoa, with experiments," 'Linn. Trans.,' vol. xxiii (tab. 33, p. 349), 1860.—*Idem*, "List of Entozoa, including Pentastomes, from animals dying at the Zool. Soc. Menagerie between the years 1857-60," 'Proceed. Zool. Soc.,' 1861.—*Idem*, 'Entozoa,' p. 20, pl. ii, 1864; and in "Manual of the Internal

Parasites of our Domesticated Animals," p. 81, 1873.—*Lewis, T. R.*, and *Cunningham, D. D.*, in a footnote to their 'Microscopical and Physiological Researches,' Appendix C., 'Eighth Ann. Rep. of the San. Comm. with the Govt. of India,' p. 168, Calcutta, 1872.—*McConnell, J. F. P.*, "On the *Distoma conjunctum*," in the 'Lancet' for 1875-76, quoted above; reprinted in the 'Veterinarian,' 1876; also (a second case) in the 'Lancet' for March 30th, 1878, p. 476.

Distoma heterophyes, Von Siebold.—This minute parasite, measuring only $\frac{3}{4}$ of a line in length, was discovered by Dr Bilharz, of Cairo, in the intestines of a lad, post-mortem, in the year 1851. A second similar instance occurred, when several hundred examples were collected and afterwards distributed amongst the helminthologists of Europe. Through the kindness of Leuckart two of the worms eventually reached myself. From one of these the accompanying figure was drawn. For the purpose of supplying a full diagnosis I have elsewhere described this worm as presenting an oblong, pyriform outline, attenuated in front, and obtusely rounded behind; body compressed throughout, the surface being armed with numerous minute spines, which are particularly conspicuous (under the microscope) towards the head; oral and ventral suckers largely developed, the latter being near the centre of the body, and about twice the diameter of the former; pharyngeal bulb distinct and separate from the oral sucker, and continued into a long œsophagus, which divides immediately above the ventral acetabulum; intestinal tubes simple, gradually widening below and terminating near the posterior end of the body; reproductive orifices inconspicuous, but evidently placed below and a little to the right of the ventral sucker, at which point they are surrounded by a special accessory organ, resembling a supernumerary sucker; uterine folds numerous and communicating with small but conspicuously developed vitelligene glands; testes spherical and placed on the same level in the lower part of the body; ovary distinct; aquiferous system terminating inferiorly in a large oval contractile vesicle, the latter opening externally by a central *foramen caudale*.

Apart from its minuteness, moreover, this trematode is especially characterised by the possession of a very remarkable apparatus surrounding the reproductive orifices. It consists of an irregularly circular disk, measuring $\frac{1}{125}''$ in diameter, and having a thick-lipped margin, which supports seventy fish-

basket-like horny ribs comparable to the claw-formations seen in the genus *Octobothrium.* According to Bilharz these ribs give off five little branches from their sides, but Leuckart could not see them in his specimens. Leuckart estimated the length of these horny filaments to be $\frac{1}{1250}''$, whilst their breadth was $\frac{1}{3570}''$. On the whole we may regard this organ as a complicated form of "holdfast" designed to facilitate or give efficiency to the sexual act. I may here also state that this structure is by no means unique; for, if I mistake not, it exists in an equally developed degree in the young trematode which Dr Leared found infesting the heart of a turtle. Leared believed that he had found an ordinary distome; an opinion to which I could not give my assent, seeing that the organ described by him as a "folded, ventral sucker" presented a very different aspect to the oral sucker displayed by the same animal. Without doubt, however, the organ in his so-called *Distoma constrictum* is analogous to the supplementary "holdfast" existing in *Distoma heterophyes.* The views which I originally advanced as to the source and condition of the parasite are probably correct.

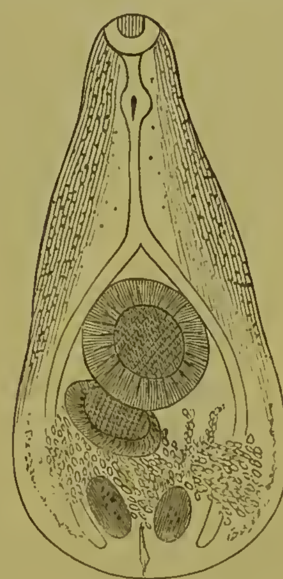

Fig. 4.—The small Egyptian fluke (*Distoma heterophyes*), viewed from behind. The large ventral sucker, supplementary disk, uterus, testes, simple divided intestine, vitellarium, and pulsatile vesicle are conspicuous. Original.

As regards the structure of *Distoma heterophyes*, I have only to add that a special set of glandular organs is situated on either side of the elongated œsophagus, but the connection between these organs and the digestive apparatus has not been clearly made out. Leuckart compares them to the so-called salivary glands found in *Distoma lanceolatum*, and says, "The presence of such a glandular apparatus is also indicated by the more ventral position of the oral sucker, and the development of the cephalic margin." The conspicuous contractile vesicle terminating the excretory system is developed to an unusually large extent, exhibiting in its interior multitudes of the well-known active molecular particles. Lastly, I have only to add that the eggs of *Distoma heterophyes* measure $\frac{1}{990}''$ in length by $\frac{1}{666}''$ transversely.

Bibliography (No. 8).—*Bilharz*, "Beitrag zur Helminth. humana," 'Zeitsch. für wissenschaftl. Zool.,' s. 62, 1851.—

Cobbold, 'Entozoa,' p. 195, 1864.—*Küchenmeister, F.*, 'Parasiten,' 1855, s. 210, Eng. edit., p. 276, 1857.—*Leared*, "Description of *Distoma constrictum*," 'Quarterly Journal of Micros. Science,' new series, vol. ii, 1862.—*Leuckart, R.*, l. c., s. 613, 1863.—*Moquin-Tandon*, on the Genus *Fasciola*, l. c., 1861.—*Weinland*, on *Dicrocœlium*, l. c., p. 86, 1858.

Distoma ophthalmobium, Diesing.—There is every reason to believe that the small flukes found by Gescheid and Von Ammon in the human eye were sexually immature worms, but since it cannot be decided as to what adult species they are referable I prefer to notice them under the usual title. Possibly these eye-worms may be referred to *D. lanceolatum*, as suggested by Leuckart. However that may be, I deem it unnecessary to repeat the details recorded in the treatises quoted below. The largest examples measured only half a line or about one millimètre in length.

FIG 5.—The eye fluke (*Distoma ophthalmobium*). Showing the suckers and intestinal tubes. After Von Ammon.

BIBLIOGRAPHY (No. 9).—*Cobbold*, 'Entozoa,' p. 191.—*Gescheid* (*D. oculi humani*), in Von Ammon's 'Zeitsch. f. Ophth.,' iii, and also in Ammon's 'Klin. Darstell. d. Krankheit d. Menschl. Auges.,' vols. i and iii.—*Küchenmeister*, Eng. edit., p. 287.—*Leuckart*, l. c., s. 610.—*Nordmann* (*Monostoma lentis*), "Mikr. Beitr.," Heft. ii, 'Vorwort,' s. ix, 1832.

Tetrastoma renale, Chiaje; *Hexathyridium pinguicola*, Treutler; and *H. venarum*, Treutler.—Whether these forms are good species or not, the fact that they were genuine parasites cannot, I think, be disputed. The first-mentioned measured five lines in length, and was found by Lucarelli in the urine. The second, eight lines long, was found by Treutler in a small tumour connected with the ovary. The third, measuring three lines in length, was twice found in venous blood, and twice in the sputum of patients suffering from hæmoptysis.

BIBLIOGRAPHY (No. 10).—*Delle-Chiaje*, 'Elmintografia Umana,' 1833.—*Bremser* (l. c., Bibl. No. 2), s. 265, 1819.—*Cobbold*, 'Entozoa' (p. 204, et seq.).—*Dujardin* (l. c., Bibl. No. 2), s. 265, 1819.—*Treutler*, 'Obs. Path. Anat. ad Helm. Corp. Humani,' p. 19, 1793.—*Zeder*, 'Anleitung zur Naturg. der Eingeweidewürmer,' s. 230, 1803.

Amphistoma hominis, Lewis, and McConnell.—The original account of this species is based upon two finds. The first series of specimens was procured from Dr J. O'Brien, of

Gowhatty, and the second set from the Pathological Museum of the Calcutta Medical College. Dr O'Brien and Dr Curran together procured their specimens, post-mortem, from an Assamese. There were hundreds of worms present in the vicinity of the ileo-colic valve. The museum specimens were procured from a patient who died at the Tirhoot gaol hospital in 1857. They were (say the authors) presented to the museum by Dr Simpson, and in the catalogue their history was briefly recorded as follows :

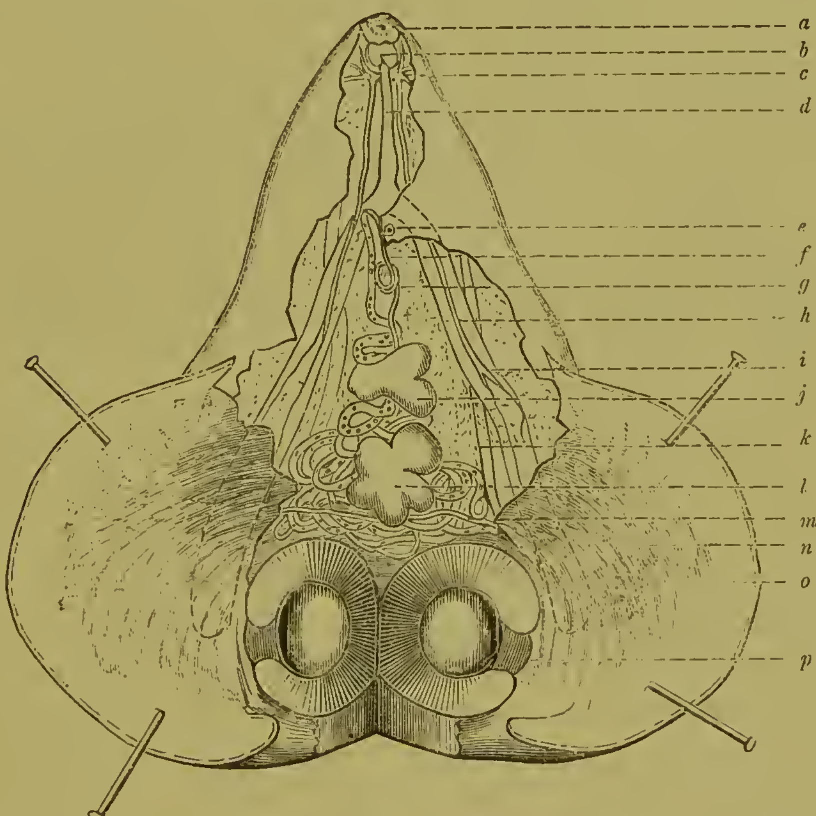

FIG 6.—The human amphistome (*Amphistoma hominis*). Longitudinal section. *a*, Oral sucker; *b*, pharyngeal bulb; *c*, nerve ganglia; *d*, œsophagus; *e*, genital pore; *f*, vagina; *g*, ductus ejaculatorius; *h*, ventral nerve cords; *i*, intestinal canal; *j*, upper testis; *k*, water vessel; *l* lower testis (ovary according to Lewis); *m*, principal ducts of the vitellarium; *n*, branches of the vitellary ducts; *o*, ventral pouch or bursa; *p*, caudal sucker. Magnified 12 diameters. After Lewis.

"The cæcum of a native prisoner who died from cholera in the Tirhoot gaol hospital, with a number of peculiar and, probably, hitherto unrecognised parasites, found alive in that part of the intestinal canal." (*Presented by Dr Simpson through Professor E. Goodeve.*)

In continuation of their narrative, Drs Lewis and McConnell go on to say that, "with reference to this preparation, the following very interesting particulars from the 'Annual Jail Report of Tirhoot' for 1857 have been very kindly placed at our disposal by the Surgeon-General, Indian Medical Department. The prisoner,

Singhesur Doradh, aged 30, was attacked with cholera on the 13th, and died on the 14th of July, 1857. Had not been in hospital previously, and was employed in cleaning the jail."

The post-mortem examination was made three hours after death:—"Colon externally livid, contracted; contains a little serous fluid with flakes of mucus. Mucous membrane healthy except venous injection. In the cæcum and ascending colon numerous parasites like tadpoles, alive, adhering to the mucous membrane by their mouths. The mucous membrane marked with numerous red spots like leech-bites from these parasites. The parasites found only in the cæcum and ascending colon, none in the small intestines." This description is by Dr Simpson, who adds, "I have never seen such parasites, and apparently they are unknown to the natives. They are of a red colour, size of a tadpole, some young, others apparently full grown, alive, adhering to mucous membrane,—head round, with circular open mouth, which they had the power of dilating and contracting. Body short and tapering to a blunt point."

Drs Lewis and McConnell's description of the worm is too long to be quoted in full. The parasites measure $\frac{1}{5}''$ to $\frac{1}{3}''$ in length, by $\frac{1}{8}''$ to $\frac{1}{6}''$ in breadth. Science is much indebted to these eminent observers for having unearthed the museum specimens and for recording the facts they could gather. From a zoological point of view the most interesting fact connected with Lewis's amphistome is the existence of a gastric pouch. This structure brings these human *Masuri* into close relation with the equine parasite which I have named *Gastrodiscus Sonsinoii*, and which will be found illustrated in this work (fig. 62). In short, Lewis's worm appears like a transition form; the absence of gastric supplementary suckerlets separating it from the new generic type.

Bibliography (No. 11).—*Lewis, T. R., and McConnell, T. F. P.*, "*Amph. hominis*; a new parasite affecting Man," 'Proceedings of the Asiatic Society of Bengal,' Aug., 1876.

Bilharzia hæmatobia, Cobbold.—This remarkable parasite was discovered by Bilharz in 1851. It was subsequently found by myself in an ape (1857); other species of the same genus having since been detected by Sonsino in the ox and sheep (1876). The human examples were originally obtained from the portal system of blood-vessels. Afterwards they were obtained by Bilharz, Griesinger, and others, from the veins of the mesentery and bladder. It was shown that they were not

only associated with, but actually gave rise to a formidable and very common disease in Egypt.

In 1864 Dr John Harley made the interesting announcement that he had discovered specimens of this singular genus in a patient from the Cape of Good Hope. He also showed that the entozoon was the cause of the *hæmaturia* known to be endemic at the Cape. Harley believed his parasites to represent a new species (*Distoma capense*), but in this view I showed that he was mistaken. His admirable contribution, nevertheless, served not only to establish the wide range of this parasite on the African continent, but also to throw much light upon the subject of endemic helminthiasis. As this worm forms an almost altogether exceptional type of fluke-structure, it became necessary to supersede the original nomenclature proposed by Bilharz and Von Siebold (*Distoma hæmatobium*). Accordingly I proposed the term *Bilharzia*, whilst other helminthologists subsequently proposed various titles (*Gynæcophorus*, Diesing; *Schistosoma*, Weinland; *Thecosoma*, Moquin-Tandon). On various grounds, and chiefly on account of priority, most writers have at length definitely accepted the nomenclature which employed the discoverer's name for generic recognition.

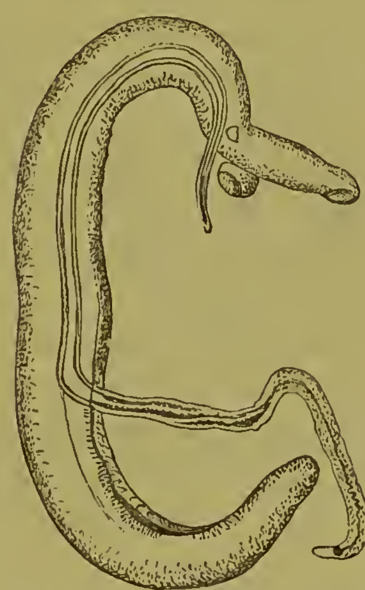

FIG. 7.—The blood fluke (*Bilharzia hæmatobia*). The lower end of the female is withdrawn from the gynæcophoric canal of the male. After Küchenmeister.

The *Bilharzia hæmatobia* may be described as a trematode helminth in which the male and female reproductive organs occur in separate individuals; the male being a cylindrical vermiform worm, measuring only half an inch or rather more in length, whilst the female is filiform, longer, and much narrower than the male, being about four fifths of an inch from head to tail; in both, the oral and ventral suckers are placed near each other at the front of the body; in the male the suckers measuring $\frac{1}{100}''$, in the female $\frac{1}{312}''$ in diameter; in either, the reproductive orifice occurs immediately below the ventral acetabulum. The comparatively short, thick, and flattened body of the male is tuberculated and furnished with a *gynæcophoric* canal, extending from a point a little below the ventral sucker to the extremity of the tail; this slit-like cavity being

formed by the narrowing and bending inwards of the lateral borders of the animal, the right side being more or less completely overlapped by the left margin of the body; caudal extremity pointed; intestine in the form of two simple blind canals. Female with a cylindrical body measuring only $\frac{1}{312}$ of an inch in thickness in front of the oral sucker; lodged in the gynæcophoric canal of the male during the copulatory act; thickness of the body below the ventral acetabulum being about $\frac{1}{357}''$, and at the lower part $\frac{1}{90}''$; surface almost smooth throughout; intestinal canals reunited after a short separation to form a broad, central, spirally twisted tube extending down the middle of the body; vitelligene and germigene canals combining to form a simple oviducal canal, which is continued into a simple uterine tube, finally opening near the lower margin of the ventral sucker; eggs pointed at one end, or furnished with a projecting spine near the hinder pole.

The study of the structure and formation of the contents of the ova possesses great interest. When fully developed the eggs are oval, measuring from $\frac{1}{180}''$ to $\frac{1}{160}''$ in length, with an average transverse diameter of $\frac{1}{325}''$. Some are a trifle larger, others smaller. Occasionally one encounters narrow specimens, and also aberrant forms presenting a pear-shaped outline. I have met with eggs not exceeding $\frac{1}{250}''$ in their long diameter, and $\frac{1}{600}''$ transversely, whose yolk-contents had already arrived at an advanced stage of segmentation.

The shell is transparent, of a brown colour, and free from any markings, lines, or sculpturing. One pole of the shell is invariably narrower than the other, and usually presents a more or less pointed extremity (fig. 8). This narrow end commonly displays a sharp, projecting, beak-like spine, which, at its base, constantly rests upon the centre of the pole of the shell, but occasionally it is eccentrically placed (fig. 8 *a*). In some few examples the spine is removed to a little distance from the actual extremity of the shell; but even in these instances, so far as my observations go,

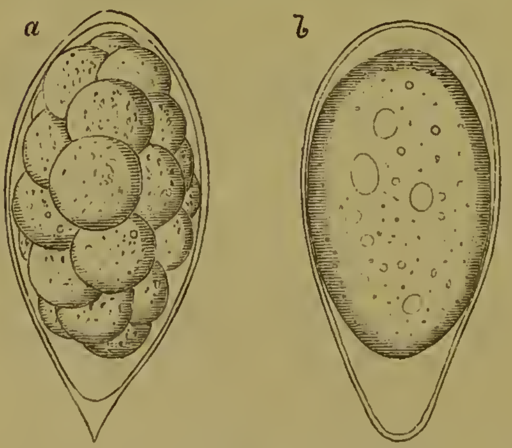

Fig. 8.—Two eggs of *Bilharzia*. *a*, With the yolk coarsely segmented; *b*, with the yolk granulated and the spine wanting. Original.

its apex always projects beyond the level of the curved end of the pole. Now and then the spine is altogether absent (fig. 8 *b*); and when present it is, as already hinted, very unequally developed. In size the spine ranges from a mere point, having an extreme length of only $\frac{1}{8000}''$, up to the comparatively large magnitude of $\frac{1}{2500}''$ lengthways.

According to the best evidence there is no good ground for asserting the existence of any specific differentiation between the parasites coming from the Cape and Egypt respectively.

Taking a more extended view of the significance of these singular chorional spines, I think we may here recognise the early efforts of Nature, so to speak, to form or evolve a special organ, which, in the eggs of certain other parasites, becomes capable of attaining a relatively prodigious degree of development. To me it seems that the little process in question is a kind of rudimentary holdfast; and, as such, it may be reckoned as the homologue of a variety of egg-appendages. Eleven years ago Mr Edwin Canton discovered some curious ova attached to the conjunctiva of a turtle's eye. I had no hesitation in pronouncing them to be referable to some ectozoon or entozoon belonging to one or other of the allied genera *Polystoma*, *Tristoma*, *Octobothrium*, and *Dactylogyrus*. Now, whilst the Bilharzia ova display only a solitary and imperfectly developed holdfast, placed at one end of the shell, the singular eggs described by Mr Canton develop organs of anchorage at both extremities. Parasitic ova exhibiting analogous processes, spines, and filamentary appendages at both poles, have been observed in various species of parasite—as, for example, in *Monostoma verrucosum* infesting the fox, in *Tænia cyathiformis* infesting the swallow, in *Tænia variabilis* of the gambet, in *Octobothrium lanceolatum* attached to the gills of the common herring; and in *Polystoma appendiculata*, from the branchiæ of various marine fishes. Eggs of parasites which,

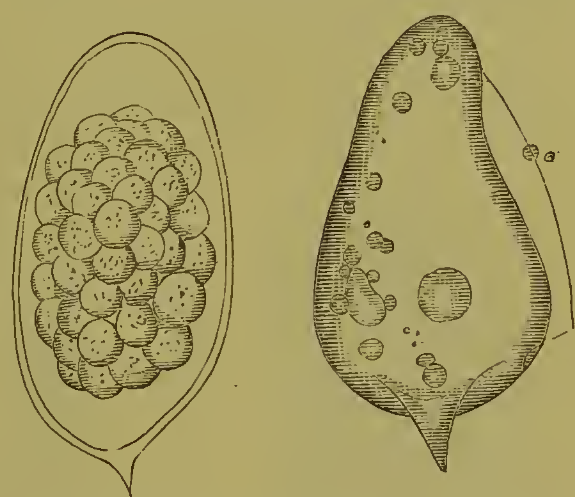

FIG. 9.—Two eggs of *Bilharzia*, with eccentrically placed spines. That to the left shows mulberry cleavage of the yolk; the other having lost its embryonal contents by rupture. Original.

like *Bilharzia,* are furnished with a single appendage, may likewise be seen in the ova of different species of *Dactylogyrus* infesting the gills of the pike. In the more strongly pronounced developments it is easy to perceive how admirably these outgrowths are adapted to the necessities of the different species of parasite to which they are severally referable; and, even in the case of *Bilharzia,* the trifling amount of anchorage furnished by a projecting point is not absolutely thrown away. The resistance will also be greater where the spine is situated a little on one side of the pole of the egg, which seems to need steadying during the violent struggles of the embryo to escape from its temporary abode.

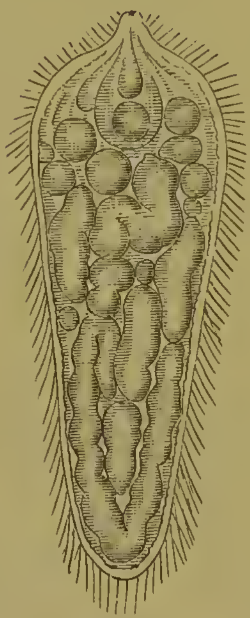

Fig. 10.—Free ciliated embryo of *Bilharzia,* with pear-shaped rudimentary organs below the head. Original.

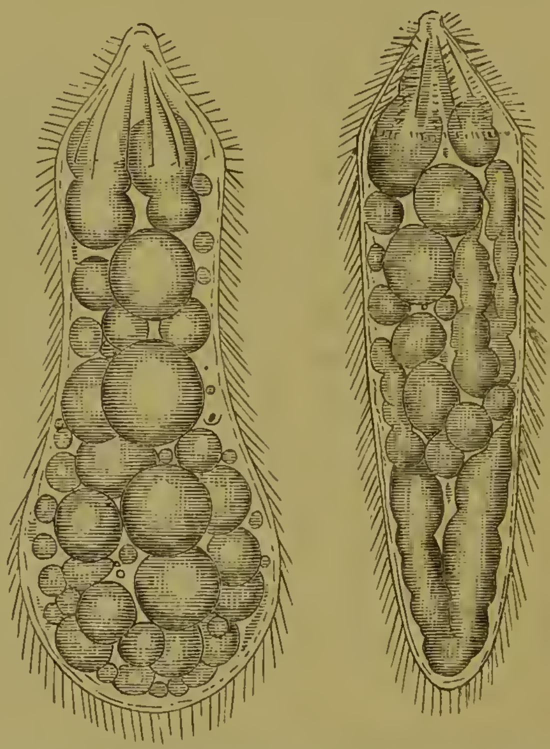

Fig. 11.—Two ciliated embryos of *Bilharzia;* showing sarcode spherules in their interior. That to the left has recently escaped the shell. Original.

When any number of ova are removed from the urine and examined, it will be found that a large proportion of them contain embryos in an advanced stage of larval growth. The structural appearances presented by the embryos whilst still in the eggs are remarkably uniform; since, in all, the yolk appears to have resolved itself into a mass of rounded sarcode-globules, one or two of these particles being conspicuously larger than the rest (fig. 12). At this stage, except towards the cephalic division of the larva, no tendency to differentiation is perceptible; but

some time after the embryo has escaped, one may notice elongated masses of sarcode formed by the coalescence of the globules. Whilst still in the egg, one end of the primitive embryonal mass becomes gradually narrowed, cilia at the same time appearing. This part becomes the future head, eventually acquiring the form of a cowl. Whatever form the body of the embryo may display after extrusion from the shell, the head retains its conical shape, the cone itself being narrowed or widened only when the larva is subjected to abnormal conditions (fig. 14). Whilst the head is undergoing development within the shell, one, two, or sometimes three, pyriform masses make their appearance within the cone; and after the embryo has escaped, these structures become more marked (fig. 10). The sarcode-globules refract light strongly; and, when the larva is not compressed in any way, they move freely within the somatic cavity. In well-developed embryos, whilst still in the egg, the cilia are observed to clothe every part of the larva except the oral papilla. This minute nipple-like projection measures about the $\frac{1}{3000}$ of an inch transversely, forming a very simple kind of unarmed proboscis. When the head of the free embryo is viewed from above, the proboscis looks like a central ring surrounded by a series of regular folds, which radiate outwards like the spokes of a wheel. The ridges thus formed support numerous cilia, these latter projecting at the circumferential margin of the cephalic cone in such a way as to present the figure of a star. Dr Harley has admirably represented this character, which is shared by many other parasitic larvæ. Throughout the greater part of the time, whilst the embryo is still resident within the egg, the broad neck or base of the cephalic cone forms a fixed point of resistance by its firm attachment to the inner wall of the shell; and this structural union, so long as it remains intact, enables the embryo to move not only its head and body from side to side synchronously, but also each part independently. When the time for final escape is drawing near, the vigorous movements of the cone-shaped head seem chiefly concerned in loosening the membranous

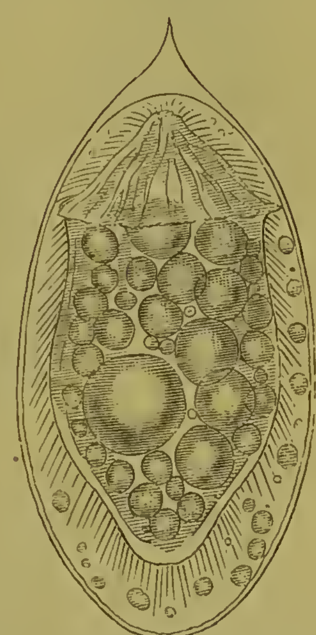

FIG. 12.—Egg of *Bilharzia*, with contained embryo and free sarcode globules. Original.

connection just referred to; and when, at length, the ciliated animalcule has succeeded in overcoming this first difficulty, it is ludicrous to witness its frantic efforts to find an opening in the shell. While thus partially liberated, it will rush to and fro from one pole of the egg to the other, performing a series of summersaults, and at the same time occasionally rolling itself over laterally. This activity becomes gradually more and more violent, until at length its excitement is worked up into a sort of frenzy. I have many times watched these performances, which, however, are only to be seen within those ova whose shells, for some reason or other, refuse to yield to the earlier aud ordinary efforts of the prisoner. In all cases where these phenomena are witnessed the eye readily detects a number of small free globules between the embryo and the inner wall of the shell (fig. 13). These minute particles are likewise tossed about tumultuously during the rapid rotatory movements of the imprisoned larva. Except as regards their size, these globules do not differ in character from the sarcodic contents of the animalcule. They are probably superfluous detachments from the primitive yolk-mass, but it is just possible that they may afford some aid in the final breaking up of the shell. Whilst the embryo remains fixed its tail is usually directed towards the narrower or spine-bearing pole of the egg, but in a few instances I have seen this position reversed. As regards the precise mode of emerging from the shell, and the time occupied by the larva in freeing itself, there are several points of interest. Speaking generally, the purer the medium into which the ova are transferred, the more rapid will be the movements of the larvæ. To give an example of observed facts in relation to the rapidity of development, I cite the following :—"On the 20th of August, 1870, I placed twelve eggs of *Bilharzia* under the microscope. The medium in which they were immersed consisted of eight parts of ordinary drinking water to one of urine. At the expiration of seventeen minutes the first-born made its escape. In the course of

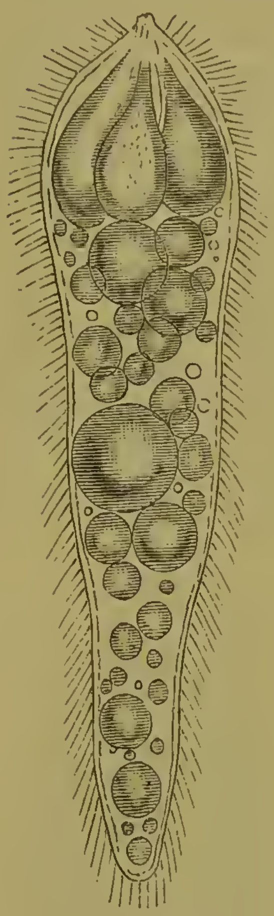

FIG. 13.—Free ciliated embryo of *Bilharzia*, slightly deformed, and having the pear-shaped organs largely developed. Original.

another minute two more emerged. In twenty-six minutes the fourth, in twenty-eight the fifth, in thirty-two the sixth, in thirty-four the seventh, in thirty-seven the eighth, in thirty-eight the ninth, in forty the tenth, in forty-three the eleventh, and in forty-six minutes the twelfth, respectively made their appearance."

Now, this rapid mode of birth and emergence from the shell is very much more striking in the case of eggs which are placed in perfectly pure water; for, whilst the eggs are still in the urine, there appears to be neither the power nor the inclination on the part of the embryo to escape; but, on isolating and placing them in suitable conditions, their behaviour is even more remarkable. In a space of less than two minutes I have repeatedly seen the hitherto motionless embryo alter its shape by contractions, become violently agitated, and burst out of its shell in the condition of a free-swimming animalcule. Moreover, it is worthy of remark that the eggs and larvæ of *Bilharzia* soon perish in stale urine. "On the 16th of August, 1870, I placed about a thousand eggs in a quart of fountain-water, to which only a drachm or rather less of urine had been added. At the expiration of forty-eight hours not a single living embryo could be found. I subsequently ascertained that I could not keep the embryos alive for twenty-four hours in any water in which I had introduced the smallest trace of mucus, blood-corpuscles, urinary crystals, or decomposing matters of any kind. All sorts of reagents speedily killed the larvæ. Mere discoloration by carmine solution, or by the addition of a drop of the solution of permanganate of potash, instantly caused them to assume grotesque and unnatural shapes (figs. 13 and 14), death sooner or later following as a result

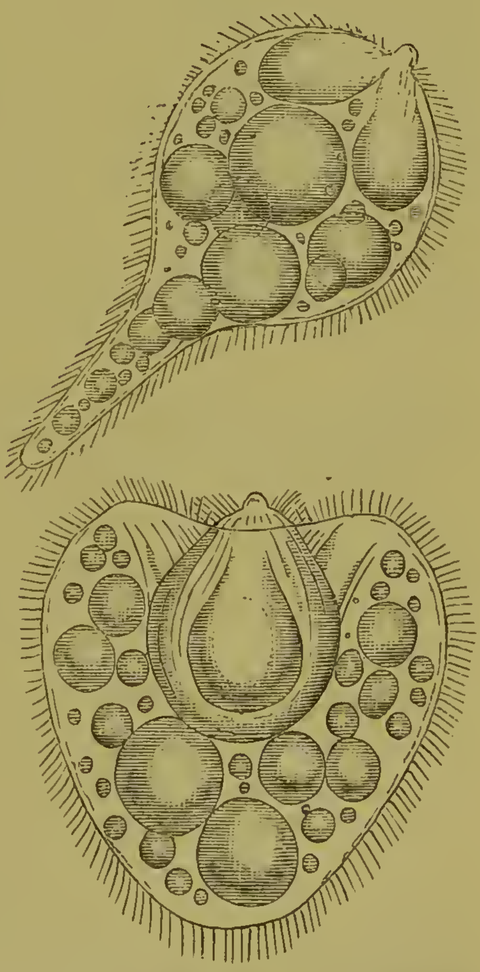

Fig 14.—Ciliated embryos of *Bilharzia*, deformed by the application of reagents. Original.

of the disintegration and resolution of their delicate bodies into mere sarcode-masses. Still more rapidly poisonous effects were produced by the addition of a little sherry or alcohol. In solutions where the amount of spirit did not exceed one part of spirit, proof strength, to fifty parts of water the effect was the same."

The development of the larva is equally well accomplished in distilled water, in well-water, and in brackish water: In pure sea-water the process goes on less satisfactorily. It was found, indeed, that the addition of slightly saline water to ciliated embryos, which were on the point of expiring in fresh water, had the effect of reviving them for a time. These facts have an important practical bearing.

I have thus shown that the escape of the embryo is by no means the slow process that Bilharz has described. Almost invariably the shell bursts by a longitudinal slit extending over fully two thirds of its long diameter, the first point of rupture being commonly situated midway between the spine and the centre of the shell. In normal births, so to speak, the head of the animalcule emerges first; but occasionally the animal escapes sideways, and I have even seen the embryo extricate itself tail foremost. Not unfrequently it has a difficulty in detaching itself from the shell, in which case the egg is whirled round and round by the half-freed prisoner (fig. 15). The lodgment of the spine, however, against any foreign substance affords the necessary leverage for ensuring escape.

The larva never displays its proper elongated, spindle-shaped, or cylindro-conical figure, until some short time after its escape from the shell; and, as a consequence of this, its powers of locomotion are less marked at first than they are subsequently. At the time of extrusion the larvæ are commonly more or less hour-glass shaped (fig. 11); this particular form being sometimes retained for many minutes or even for an hour. Usually the larvæ have a tendency to acquire their normal shape immediately after quitting the shell; the oval, pear-shaped, and variously contracted forms gradually merging into the characteristic cone-shaped animalcule (fig. 10). In their fully developed condition, they exhibit the most lively movements; and to witness several hundreds of them rushing about with unceasing activity is a curious sight. The phenomenon, moreover, loses none of its interest from the consideration that only a few hours, or it may have been minutes, previously, these now actively

gyrating animalcules were lodged *in ovo* within the blood-vessels of their human host. From persons who are infested, myriads of these eggs of *Bilharzia* daily make their escape during the act of micturition; and, when this act is accomplished by the host out-of-doors, it is easy to perceive how readily the ova may be subjected to conditions favorable to the development of larvæ. The direct passage of the urine into any considerable receptacle of natural or fresh water would in a few minutes ensure the hatching of all the eggs; and in the absence of any such direct aid to development, the accidental occurrence of a shower of rain would, in all localities where the *Bilharzia* disease is endemic, readily transfer the ova into ditches, ponds, rivers, lakes, and ultimately, perhaps, even into the sea itself.

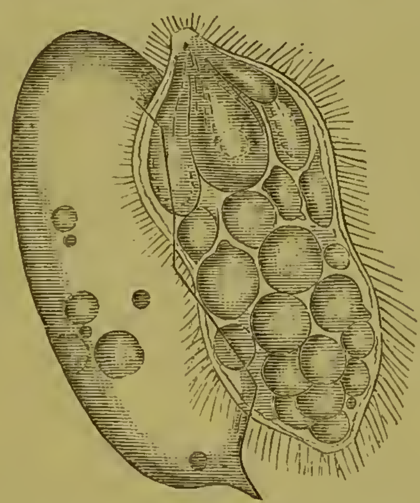

Fig. 15.—Egg of *Bilharzia*, with the shell still adhering to the escaped ciliated embryo. Original.

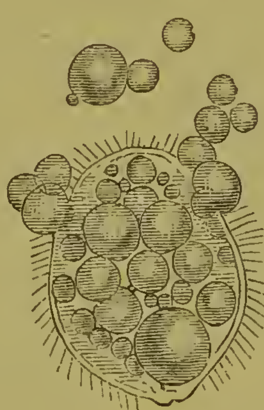

Fig 16—Ciliated embryo of *Bilharzia* in the act of dying from the escape of its sarcodic contents. Original.

The behaviour of the embryo under the action of reagents of various kinds is remarkable. Thus, when on the 5th of Sept., 1870, I placed some ova in brackish water, of the strength of two parts of fresh water to one of pure sea-water, their contents were readily developed, though the escaping embryos did not swim vigorously. When again I placed some other eggs in pure sea-water, their contained embryos became instantly transfixed, the vibratile cilia of the head being rigid and motionless. At first I naturally concluded that the embryos were killed outright; but, to my great surprise, the shock passed away in about half an hour, when they revived and were soon afterwards hatched. One of the larvæ thus set free carried off several of the loose intra-chorional globules which had, during the period of transfixion, become firmly adherent to the ends of the caudal cilia. Here I may remark upon a decided difference observable

between the cilia of the head and body respectively. The former are at all times vibratile, active, and conspicuous, whilst the latter are more delicate, capable of comparatively little motion, and partaking more of the character of fine setæ. In length their general measurement varies from $\frac{1}{2500}''$ to $\frac{1}{2000}''$. The action of pure sea-water on the free animalcules, previously immersed in fresh or brackish water, was equally striking. All, without exception, immediately became paralysed and almost motionless; nevertheless, on again adding fresh water, several entirely recovered. It is worthy of notice that in these cases the cephalic cilia furnished the first indications of returning viability. I was particularly struck with the behaviour of one embryo, which, under the stimulus of the sudden shock, retracted its cone-shaped head almost entirely within the general cavity of the body (fig. 14, lower specimen). In their moribund condition, whatever shape the embryo retained, the sarcodic contents gradually faded away; the outline of the creature, however, becoming more marked (fig. 16). Usually the body of the animalcule became elongated whilst expiring in sea-water. Under other circumstances the embryo frequently bursts; the sarcodic contents escaping in the form of amœba-like bodies and the cilia retaining their powers of movement long after all traces of the sarcode have disappeared.

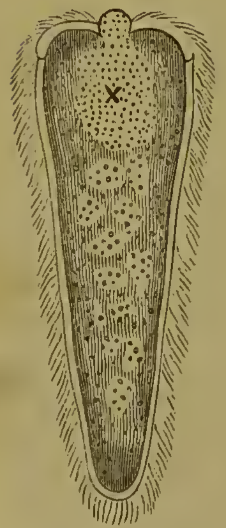

Fig. 17.—Ciliated embryo of *Fasciola hepatica*, showing the so-called eye-spot. After Leuckart.

The larvæ of *Bilharzia* closely resemble those of *Fasciola hepatica*, which latter may be appropriately noticed in this place. The ciliated embryo of the common liver fluke has the form of a long cone inverted; the anterior end or head being flatly convex. In the centre is a short proboscis-like papilla destitute of cilia (fig. 17). The general covering of cilia rests on a well-defined granular epidermis; this latter being succeeded by a dense peripheral layer of large nucleated cells, each of them measuring about $\frac{1}{2500}''$ in diameter. The epidermis measures $\frac{1}{6250}''$ in thickness. In the central mass of parenchyma no internal organs are recognisable, but Leuckart observed indications of a canal which he thought might open at the tail, though the opening itself was not actually visible.

As long as the ciliated covering remains intact the embryo, like other animalcules, displays great activity, whirling round

and round on its own axis, and also describing gyrations and circles of different degrees of range in the water, the latter movements being accomplished by bending the body upon itself to a greater or lesser curvature. The embryos of *Bilharzia* and other infusoria exhibit the same behaviour, and, as Leuckart observes, when these embryos knock against any obstruction, they pause after the blow, as if to consider the nature of the substance they have touched. As in the case of fluke embryos generally, the ciliated covering eventually falls off and the embryo reassumes a more or less oval figure, at the same time changing its swimming mode of progression for the less dignified method of creeping. In the free ciliated condition the embryo of the common liver-fluke measures, according to Leuckart, $\frac{1}{190}''$ in length, the anterior broad end being $\frac{1}{500}''$. The cilia have a longitudinal measurement of $\frac{1}{1388}''$.

According to the observations of Dr Willemoes-Suhm, the cilia of the embryos of the *Distoma megastoma* are limited to the anterior pole of the body. This is also the arrangement, as Leuckart first pointed out, in *Distoma lanceolatum* (fig. 18). On the other hand, Pagenstecher has shown that the embryos of *Distoma cygnoides* and *Amphistoma* (*Diplodiscus*) *subclavatum* are ciliated all over, an observation which, as regards the latter species, has been confirmed by Wagener and others. Dr Pagenstecher's original statement to the effect that "intrachorional germs of trematodes offer no distinctive characters," must, therefore, in the present state of our knowledge, be accepted as a general conclusion admitting of many exceptions. In the early stages of development the embryo of *Distoma lanceolatum* occupies the centre of the egg, and according to Leuckart has its conical head invariably directed towards the upper pole of the shell, or, in other words, to that end of the egg which is furnished with a lid-like operculum. Leuckart describes the embryo itself as "finely granular and armed at the tip with a dagger-like spine, which, with the simultaneous displacement of the adjacent granular mass, can be pushed forward and drawn back again." Besides this so-called cephalic granular mass, there are within the embryonic body two other granular masses widely separated from each other, but occupying the posterior half of the embryo. These Leuckart supposes to be the rudiments of a future brood, to be developed at the time when the free embryo shall have lost its ciliated swimming apparatus, shall have bored its way by means of the cephalic

spine into the tissues of a mollusk, and shall have become metamorphosed into a sac-like larva (Nurse, Sporocyst, or Redia, as the case may be). Whatever be the full significance of these internal developments, we have at least satisfactory evidence that the complete and free embryo is a globe-shaped animalcule, having the anterior third or cephalic end of the body covered with cilia, and armed with a central boring spine. In consequence of this limitation of the ciliated covering, its swimming movements are less vivacious than those of the embryo of *Fasciola hepatica*; it will, therefore, probably take up its residence in a less active host than that chosen by the embryo of Fasciola, selecting one of those mollusks which either move slowly or are prone to keep at the bottom of the water. The mature eggs have a length of $\frac{1}{625}$ to $\frac{1}{555}$ of an inch, and a breadth of $\frac{1}{833}''$. The long diameter of the free embryo varies from $\frac{1}{990}''$ to $\frac{1}{833}''$, the transverse diameter being $\frac{1}{1562}''$. Whilst the embryos were still in the egg Leuckart could see no ciliary motion. With most observers, both the ciliary apparatus and the boring spine appear at this stage to have altogether escaped observation.

FIG. 18.—Ciliated embryo of *Distoma lanceolatum*. After Leuckart.

As regards the intimate structure of the ciliated embryo of *Bilharzia hæmatobia*, I have further to observe that, shortly after its extrusion from the shell, the hitherto loose, globular sarcode particles coalesce. This is apparently a preliminary step towards the subsequent differentiation process. Respecting the pedunculated blind sacs formed within the head, I think that we must regard the largest one as representing the stomach of the larva in its future cercarian stage. Under the $\frac{1}{12}''$ objective I distinctly recognised, in the cavity of the central blind sac, numerous highly refracting granules, the diameter of which averaged not more than $\frac{1}{12000}''$. The rudimentary stomach is often traceable whilst the larva is still within the egg. It measures about $\frac{1}{500}''$ in length, including the peduncle, and $\frac{1}{14000}''$ in breadth. The width of the narrow stalk does not exceed $\frac{1}{9000}''$. The other two-stalked bodies appeared to have the character of *lemnisci*. They were occasionally well seen whilst the embryo was still within the egg. As regards the integument, it is easy to recognise two layers. In careful adjustments of the focus the inner wall of the transparent dermis presents a beaded appearance. These minute and

regular markings do not undergo alteration during the contractions of the body of the larva.

A highly developed water-vascular system exists in these little animalcules. On many occasions I saw traces of this set of vessels, and in several instances I obtained a most satisfactory view of the entire series of branches. Anxious to receive confirmation of my discovery, I demonstrated the existence of these vessels to a skilled microscopist—the late Mr J. G. Pilcher, of H. M. Army. In the briefest terms it may be said that the water-vascular system of *Bilharzia*, in the larval condition, consists of two main stems, which pursue a tortuous passage from head to tail, and which, in the course of their windings, give off several anastomosing branches (fig. 19). As also obtains in the corresponding larvæ of *Diplodiscus subclavatus*, there is no excretory outlet visible at the tail.

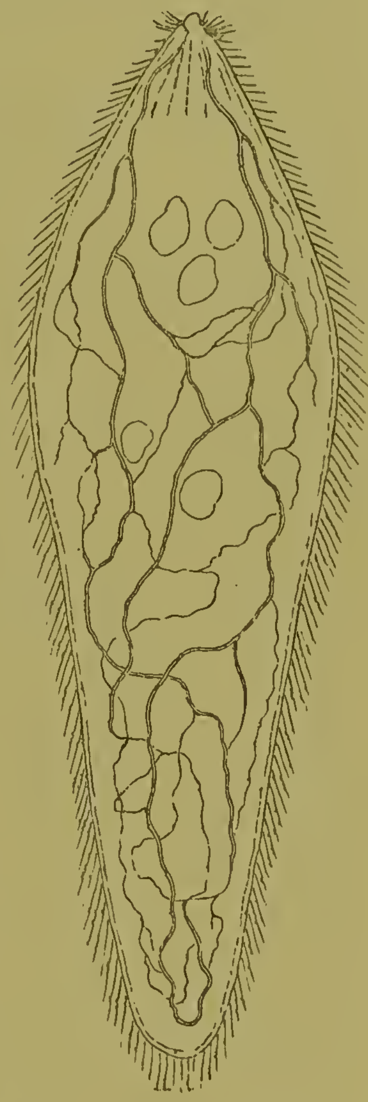

FIG. 19.—Outline representation of a ciliated embryo of *Bilharzia*, showing the arrangement of the water vessels and the vacuoles. Original.

Encouraged by the experiences and determinations of Pagenstecher, Filippi, Wagener, Leuckart, and others, I sought for the intermediate hosts amongst fresh-water mollusks and small crustacea. Failing of success in these, it occurred to me that the larvæ of *Bilharzia* might normally reside in fluviatile or even in marine fishes. This latter idea seems also to have struck Dr Aitken. In an appendix to his 'Report to the Army Medical Department for 1868,' dated from Netley, Nov., 1869, he gives a figure of a nurse-form, which he terms a cercaria, from the tail of a haddock—suggesting for *Bilharzia* some genetic relation. Dr Aitken also extends his views in reference to certain larval trematodes alleged to have been found in the so-called Delhi boils and Lahore sores. These parasitic forms have, however, been shown by Dr Joseph Fleming to be nothing more than altered hair-bulbs ('Army Med. Reports,' 1868-69).

In regard to the flukes from the haddock, I have satisfied

myself that these immature trematodes from the nerves of the cod-tribe can have no genetic relation with *Bilharzia;* and I think it due to Dr Maddox to say that I accept his conclusion respecting them. In his paper ('Micros. Trans.,' vol. xv, 1867, p. 87) he offers strong proof that the so-called *Distoma neuronaii Monroii* of the haddock (*Morrhua æglefinus*) is the juvenile condition of *Gasterostoma gracilescens* of the angler (*Lophius piscatorius*).

I am sorry to have to state that all my experiments proved negative. I tried to induce the ciliated embryos to enter the bodies of a variety of animals, such as Gammari, Dipterous larvæ, Entomostraca, Lymnæi, Paludinæ, different species of Planorbis, and other mollusks; but neither in these, nor in Sticklebacks, Roach, Gudgeon, or Carp, did they seem inclined to take up their abode.

The very peculiar and formidable helminthiasis produced by this parasite has been thoroughly investigated by Griesinger and Bilharz, and it has been fully described in the standard works of Küchenmeister and Leuckart. My own case from Natal also supplied many interesting clinical facts which were published in my 'Lectures on Helminthology,' quoted below. The comparative prevalence of this disorder in Egypt is well established. Symptomatically, its principal feature consists in a general disturbance of the uropoietic functions. Diarrhœa and hæmaturia occur in advanced stages of the complaint, being also frequently associated with the so-called Egyptian chlorosis, colicky pains, anæmia, and great prostration of the vital powers. The true source of the disorder, however, is easily overlooked unless a careful microscopic examination be made of the urine and other evacuations. If blood be mixed with these, and there also be a large escape of mucus, a minute inspection of the excreta will scarcely fail to reveal the presence of the characteristic ova of *Bilharzia.* Besides the increase of mucus secretion, there may even be an escape of purulent matter, showing that the disorder has far advanced. The patient's constitution eventually becomes undermined; pneumonia often sets in, and death finally ensues. On making post-mortem examinations the following pathological facts come to light. In cases where the disease has not advanced very far, minute patches of blood-extravasation present themselves at the mucous surface of the bladder, but in more strongly pronounced cases the patches are larger or even

confluent. In some instances there are villous or fungus-like thickenings, ulceration and separation of portions of the mucous membrane, with varying degrees of coloration, according to the amount of the extravasation, which becomes converted into grey, rusty-brown, or black pigment deposits. A gritty or sandy deposit is often superimposed, consisting of ordinary lithic-acid grains mixed with eggs and egg-shells. Eggs are readily detected in the urine, these having escaped from the ruptured vesical vessels. The lining membranes of the ureters and renal cavities are also more or less affected; the kidneys being frequently enlarged and congested. It must, however, be borne in mind that in all these organs the true seat of the disorder is the blood, which forms the proper habitat of the *Bilharzia*; and this being the case, the worms as well as their escaped eggs may be found in any of the vessels supplying the diseased organs. In one instance, quoted by Leuckart, Griesinger found a number of empty eggs in the left ventricle of the heart, and from this circumstance it was supposed that they might be carried into various important organs, or even plug up the larger vessels. As before stated, however, the parasites are more particularly prevalent in the vessels of the bladder, mesentery, and portal system. The effects upon the intestinal mucous membrane are, in most respects, similar to those occurring in the urinary organs. Blood extravasations, with thickening, exudation, ulceration, and fungoid projections, appear in and upon the intestinal mucous and submucous tissues; these appearances, of course, being more or less strongly marked according to the degree of infection.

In regard to the treatment of the helminthiasis, I am precluded from entering into details here; nevertheless, I am glad to perceive that the principles which I long ago enunciated have received approval both at home and abroad. As stated in my 'Lectures' our object should be not to interfere with, but to promote nature's curative efforts. If I read the pathological facts correctly, she seeks to bring about this result by erecting artificial barriers which serve to moderate the bleeding. In this way, under ordinary circumstances, the life of the bearer is sustained, or held in the balance until the parasites either perish or cease to be capable of causing active disease. Depend upon it, this is the principle which should guide physicians in their treatment of the Bilharzia disorder. If the adult parasite were merely attached to the lining membrane of

the bladder, then powerful diuretics and medicated injections would probably prove serviceable; but since the entozoa reside in the blood we must be careful not to increase the patient's troubles. In the case of intestinal worms the most powerful parasiticides may be prescribed without let or hindrance; but that drug must be a truly subtle worm-poison which, when taken into the system, shall kill the blood-flukes without exerting any injurious effects upon the parasite bearer.

When, in 1872, I published my lectures on helminthology, I remarked that it was not improbable that, ere long, many more cases of Bilharzia disease would be brought to light. What has been added in this respect is chiefly due to the researches of Sonsino, but a case of some interest has been recorded comparatively recently by Dr W. K. Hatch, stationed at Bombay. From the particulars furnished it seems evident that the victim, an English gentleman, contracted the disease by drinking water, either in Arabia or in Egypt, in which latter country, however, he had only sojourned fifteen days. From the patient's statements it appears that, hæmaturia is frequent amongst the Arabs. Incidentally, Dr Hatch mentions that Dr Vandyke Carter had informed him that, so early as the year 1862, he (Dr Carter) had detected the embryos of Bilharzia in the urine of an African boy admitted to the Jamsetjee Jejeebhoy Hospital. The treatment employed by Dr Hatch was that recommended by Dr Harley in his well-known memoir. Having myself energetically opposed Dr Harley's views on pathological grounds, I am not surprised to see it stated that Dr Harley's method of treatment effected "no diminution in the number of the parasites." As I said in my lectures (now out of print) it is evident that "nature" in view of moderating the hæmaturia—by the formation of plugs at the ulcerated points of the mucous surface—sets up the artificial barriers above referred to; therefore if you catheterise and employ medicated injections you do more harm than good. As to the administration of belladonna internally, in view of retarding development, or of destroying the parasite, no good can be expected from this source. I certainly obtained better results with buchu and bearberry (*Arctostaphylos*).

In the matter of sanitation it is quite evident, from the foregoing data, that the danger of infection cannot arise from the drinking of impure water, as ordinarily understood. The embryonal larvæ would be killed by an admixture of sewage.

It is obvious that infection can only occur from swallowing free cercariæ or freshwater mollusks which contain the higher larval forms in their encysted or pupa condition. Slow running streams or stagnant pools with sedgy banks are eminently favorable to the existence and multiplication of intermediary bearers, and consequently their waters are dangerous if employed for drinking purposes.

Bibliography (No. 12).—*Bilharz,* in Siebold and Köll., 'Zeitsch. für wissensch. Zool.,' iv, 1851.—*Idem,* 'Wiener medic. Wochenschrift,' 1856.—*Cobbold, T. S.,* "On some new forms of Entozoa (*Bilharzia magna*)," 'Linn. Trans.,' vol. xxii, p. 364, 1859.—*Idem,* "Synopsis of the Distomidæ," in 'Proceed. Linn. Soc.,' vol. v, Zool. Div., p. 31, 1860.—*Idem,* "Remarks on Dr J. Harley's *Distoma capense,*" in 'Lancet,' also in the 'Veterinarian,' and in 'Intell. Observer' for Feb. and March, 1864.—*Idem,* "Entozoa," l. c., p. 197, 1864.—*Idem,* "On Blood Worms," Lecture xx in 'Worms,' l. c., p. 145 et seq., 1872; Tommasi's edit., Vermi, p. 141, 1873.—*Idem,* "On the Embryos of *Bilharzia,*" 'Brit. Assoc. Rep.,' 1864.—*Idem,* "On the Development of *Bilharzia hæmatobia,* together with Remarks on the Ova of another Urinary Parasite occurring in a case of Hæmaturia from Natal," 'Brit. Med. Journ.,' July, 1872; repr. in the 'Veterinarian,' 1872.—*Idem,* 'New Entozootic Malady, &c.' (brochure), London, 1865.—*Idem,* "Helminthes," in Gunther's 'Record of Zool. Literature,' p. 617, 1865.—*Idem,* "Entozoa in relation to Public Health and the Sewage Question," Rep. of the Proceed. of the Metrop. Assoc. of Officers of Health, in 'Med. Times and Gazette,' Jan., 1871, repr. in the 'Veterinarian,' p. 359, 1871.—*Idem,* "Verification of recent Hæmatozoal Discoveries in Australia and Egypt," 'Brit. Med. Journ.,' June, 1876.—*Idem,* "On Sewage and Parasites, especially in relation to the Dispersion and Vitality of the Germs of Entozoa," rep. in 'Med. Times and Gaz.' for Feb., and the 'Veterinarian' for May, 1871.—*Davaine, C.,* l. c., 'Synops,' and p. 312, 1860.—*Diesing, C. M.,* 'Revis. d. Myzelmith,' Vienna, 1858. —*Griesinger,* "Klin. und Anat. Beobachtungen über die Krankheiten von Egypten," in 'Arch. für physiol. Heilkunde,' 1856.—*Idem,* 'Gesammelte Abhandlungen,' Berlin, 1872.—*Idem,* 'Arch. d. Heilk.,' 1866.—*Harley, J.,* 'On the Hæmaturia of the Cape of Good Hope, produced by a Distoma,' rep. in 'Lancet,' and 'Med. Times and Gaz.,' Feb., 1864; also in Ranking's 'Abstract,' p. 173, 1864, and fully in 'Medico-Chirurg.

Trans.,' 1865.—*Idem*, "On the Endemic Hæmaturia of the South Eastern Coast of Africa," 'Med.-Chir. Trans.,' vol. liv, 1871.—*Idem*, in Hooper's 'Vade Mecum,' 1869.—*Hatch, W. K.*, "Case of *Bilharzia hæmatobia*," in 'British Medical Journal,' Dec. 14, 1878, p. 875.—*Küchenmeister, F.*, 'Parasiten,' 1855; Eng. edit., p. 277, 1857.—*Leuckart, R.*, l. c., s. 617, 1863.—*Sonsino, P.*, "Richerche intorno alla Bilharzia hæmatobia in relazione colla Ematuria Endemica dell' Egitto e nota intorno un Nematoideo trovato nel Sangue Umano," 'Estr. dal Rend., del. R. Accad.,' 1874.—*Idem*, 'Della Bilharzia hæmatobia e delle alterazione Anatomo-patologiche che induce nell' Organismo Umano, loro importanza come Fattori della Morbilità e Mortalità in Egitto, con cenno sopra una Larva d'Insetto Parassita dell' Uomo. Estratto dall' Imparziale,' Firenze, 1876.—*Idem*, 'Sugli ematozoi come contributo alla Fauna Entozooca Egiziana,' Cairo, 1877.—*Idem*, "La Bilharzia hæmatobia, et son rôle Pathologique en Egypte," 'Arch. Gén. de Médicine,' for June, p. 650, 1876.—*Idem*, "Intorno ad un nuovo Parassita del bue (*Bilharzia bovis*)," 'Estr. dal Rend. del. R. Accad. di Napoli,' 1876.—*Weinland, D. F.*, l. c., p. 67, 1858.

SECTION II.—CESTODA (Tapeworms).

Tænia mediocanellata, Küchenmeister.—This cestode is frequently spoken of as the unarmed or beef tapeworm. In general appearance it is very similar to the armed form. It is, however, a larger and broader animal, being at the same time rather stouter. It varies usually from fifteen to twenty-three feet in length, but specimens have been described as attaining thirty feet. It is called the unarmed tapeworm in consequence of the absence of any coronet of hooks on the head; and consequently, also, from there being no prominent rostellum or proboscis. The place of the last-named structure, however, is supplied by a small rudimentary disk, which I have seen protruded on pressure (fig. 20). Usually this disk forms a more or less conspicuous cup-shaped circular depression, which has been compared to and described as a fifth sucker. That it is not, in any structural sense, comparable to the true suckers, I have had abundant opportunity of ascertaining; nevertheless, I do not doubt that it is to a slight extent capable of being used by the parasite as a supernumerary holdfast. The anchorage thus secured, however, is by no means equal to that obtained by the armed species.

This explains the comparative difficulty we find in procuring a specimen of the armed tapeworm with the head attached.

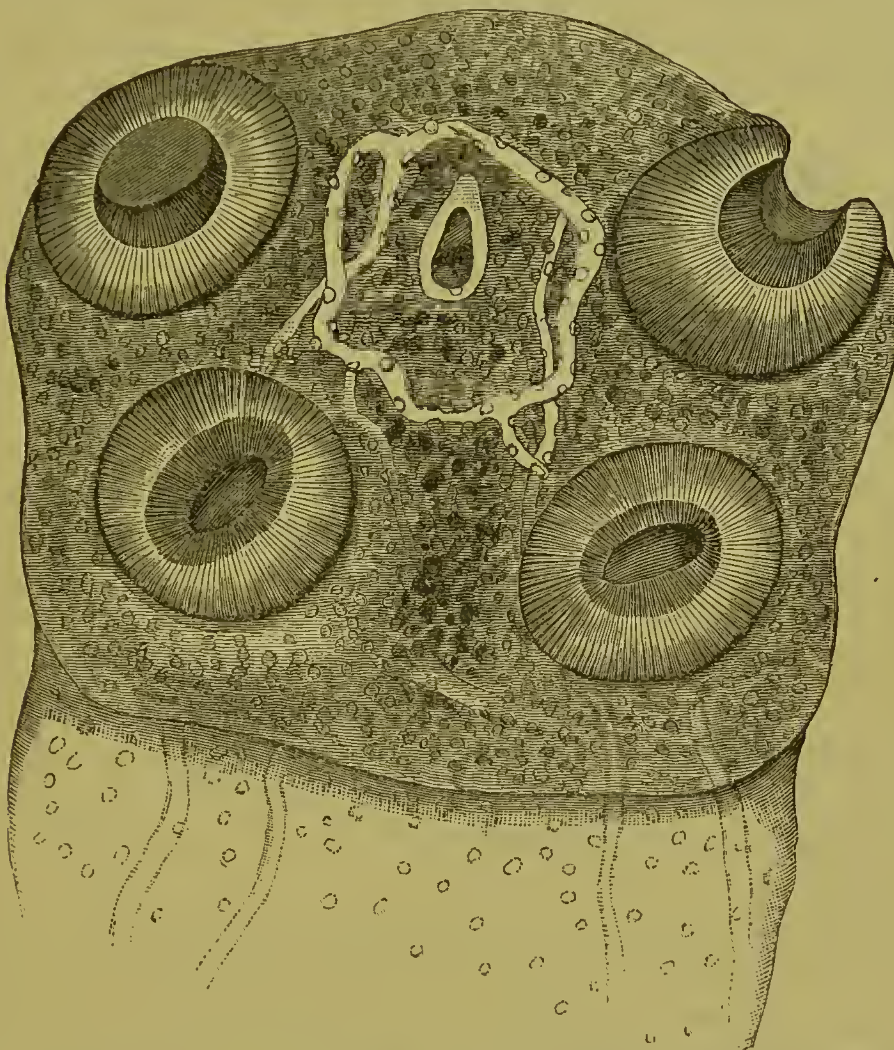

FIG. 20.—Head of *Tænia mediocanellata*. Showing the calcareous corpuscles, suckers, rudimentary proboscis, and water vessels. Highly magnified. Original.

The establishment of this species as distinct from *T. solium* is due to Küchenmeister; but it is curious to observe how accurately this determination was foreshadowed by the shrewd naturalist and theologian, J. A. E. Goeze, who clearly indicated two forms of the common tapeworm, remarking (l. c., Bibl. No. 1, s. 278):—"Die erste ist die bekannte grosse, mit langen dicken und gemästeten Gliedern, die ich *Tænia cucurbitina, grandis, saginata,* nennen will." The same author (s. 245) pointed out the resemblance subsisting between the tapeworm of the cat (*T. crassicollis*) and the vesicles ("Krystallblasen") and their contained "erbsförmige Blasen" (*Cysticercus fasciolaris*) of the mouse. Thus the celebrated pastor of St Blasius, in Quedlinberg, almost contemporaneously with Pallas, early

arrived at the conclusion that the hydatid-measle was a kind of tapeworm.

Respecting the organisation of this worm I may observe that the mature joints have a more complicated uterine organ than obtains in *Tænia solium*, presenting nearly double the number of lateral branches. They are more closely packed, running outwardly in an almost parallel manner. The first sexually mature proglottis occurs at about the 450th joint, but whereas, in the pork tapeworm, only some 200 subsequent segments share this perfect character in the beef tapeworm, according to Leuckart, as many as 360 or even 400 mature joints may be present. The joints are very liable to form monstrosities; these abnormalities sometimes affecting the reproductive organs, which become doubled or even trebled. In the Hunterian collection there is a proglottid showing twenty-two sexual orifices. Dr Cullingworth, of Manchester, has described a specimen in which the joints are curiously tripartite.

FIG. 21.—Free proglottides of *Tænia mediocanellata*. After Leuckart.

As already hinted the true source of this parasite has been proved by experiment; the first successful worm-feeding having been accomplished by Leuckart. Mosler's, and subsequently my own feeding experiments, immediately followed. Other successful experiments with this species have been conducted by Zurn, Probstmayer, St Cyr, Perroncito, Masse and Pourquier, and Zenker. As will be again mentioned below Dr Oliver, R.A., whilst stationed at Jullundur, successfully reared the adult tapeworm in a Mohammedan groom and in a Hindoo boy. It will also be seen that Prof. Perroncito reared the worm in a student in fifty-four days. In my own experiments on animals I was assisted by Professor Simonds. The feeding materials were tapeworms expelled from my own patients. We obtained the following interesting results:

Exp. 1.—A calf. First feeding, Dec. 21st, 1864. Marked symptoms. Slaughtered April 3rd, 1865. Result positive.

Exp. 2.—A calf. First feeding, April 13th, 1865. Second, third, and fourth feedings in May and June. No symptoms. Died on Sept. 3rd, 1865, after thirty-six hours' illness with "cattle

plague." Result stated to have been negative as far as the muscles were concerned. Viscera not examined.

Exp. 3.—A Dutch heifer. First feeding, March 3rd, 1865. Three subsequent feedings. Symptoms only slight. Slaughtered April 4th, 1866. Result positive. Measles especially numerous in the diaphragm, but all had undergone calcareous degeneration.

Exp. 4.—A calf. Fed May 27th, 1872, with ripe proglottides. Marked symptoms set in on June 7th, which began to abate on the 12th, and had nearly disappeared by the 20th of the same month. The record of the post-mortem result has been lost; but the animal was infected.

Exp. 5.—A calf, which had been made the subject of a "glanders experiment." First fed on Oct. 17th, 1872, and thrice in the following year, Jan. 1st and 11th, and March 8th. No symptoms having appeared the animal was kept for six or eight months after the last feeding. Seeming to be free from disease of any kind, it was sold as a sound heifer.

Exp. 6.—A young heifer calf, of six months. Fed Oct. 18th, 1873, with the mature proglottides of a large beef tapeworm. No symptoms. Slaughtered several months afterwards. Result *stated* to have been negative. Unfortunately I was not present at the autopsy.

Exp. 7.—A young heifer. First fed May 19th, 1874, with the joints of a tapeworm, and again on June 12th. No apparent ill effects resulted, but the animal died in October. At the post-mortem examination, made by Prof. Simonds, no parasites were observed. Subsequently I found calcareous specks in the liver which proved to be degenerated measles.

Exp. 8.—A calf. Fed on or about March 24th, 1875, with sexually mature joints. The calf was put to and remained with a foster mother until it died from disease of the larynx on the 15th of the following July. The animal was ill-treated by its foster parent, and at the post-mortem I observed a large intercostal cicatrix, evidently the result of injury. In this case I devoted several hours to the exploration of the muscles and viscera. Not a trace of the *Cysticercus bovis* could be found in the muscles or connective tissues, but the liver contained scores of perfectly developed measles, besides hundreds of others in various stages of calcareous degeneration. On comparing some of the latter with those I had obtained from the preceding experiment the pathological appearances were at once seen to be

identical. It was easy to find and pick out the measles in their cysts from the naturally friable liver. I also detected four Cysticerci in the lungs, two of which had degenerated. Microscopic examination confirmed my interpretation of the naked-eye appearances.

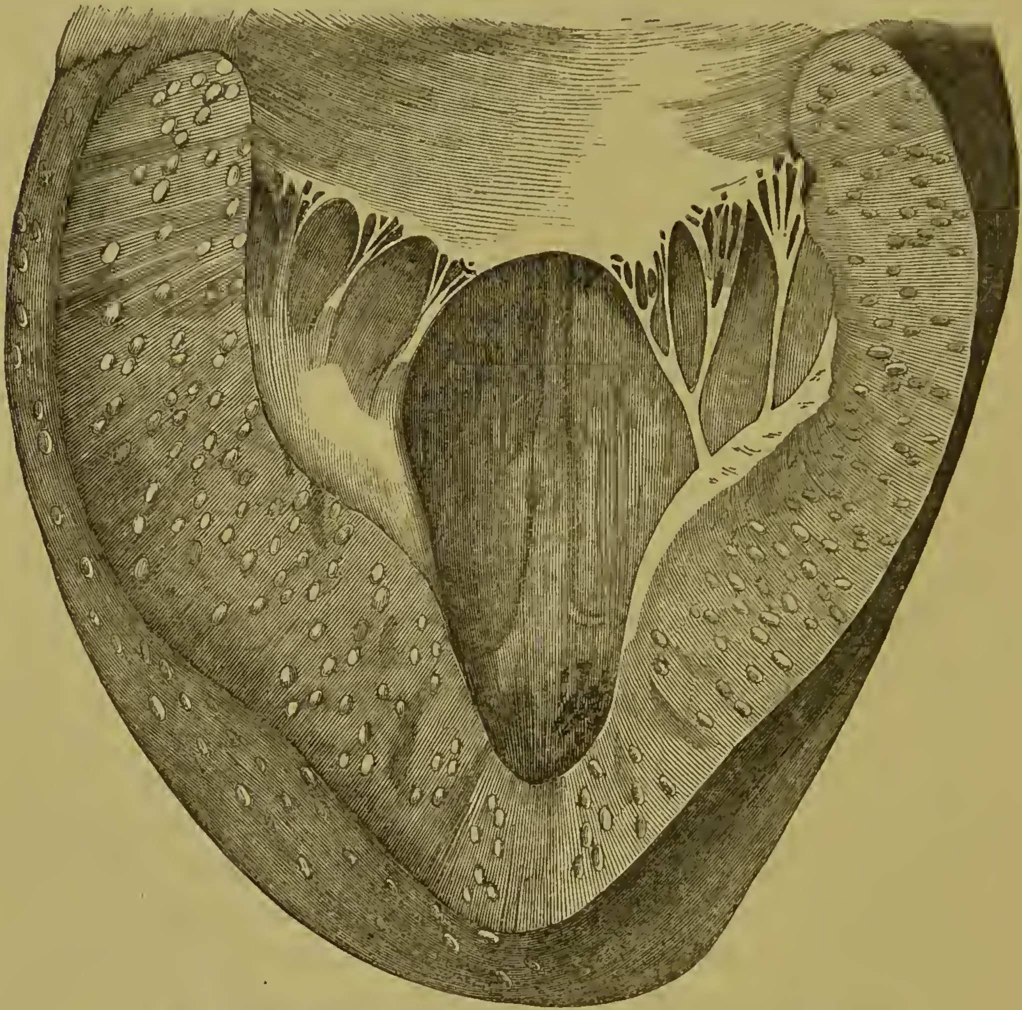

FIG. 22.—Section of the heart of a calf infested by cestode larvæ. After Mosler.

Fragmentary as the above data are, they serve to show that we have hitherto been too hasty in concluding that beef and veal measles reside only in the voluntary and striated muscles of their hosts. The facts here recorded prove that the liver of a calf may be extensively invaded by cysticerci, and yet the animal will exhibit no sign of constitutional disturbance. The cestode tuberculosis may come and go without any diagnostic symptom, whilst a few months suffice for the natural death and decay of the parasite by calcareous degeneration. Thus it becomes extremely probable that many experiments hitherto regarded as negative in their results have really been positive; the pathological evidences having been either misinterpreted or

altogether overlooked. Every pathologist is familiar with gritty particles in the various viscera of man and animals, but few are probably aware how constantly these are dead and degenerated Cysticerci. The gritty particle itself may be reduced to the merest point, no larger than the *receptaculum capitis* of the Cysticercus itself, and in course of time it will disappear entirely. Practically it is satisfactory to have experimental evidence of the fact that cattle, as well as other animals, however extensively measled they may have been, can become thoroughly cleansed of the disorder by nature herself. It is only necessary that the diseased animals be separated from infectious influences.

Although the beef measle has never yet been found in man, I have for convenience sake introduced the facts of larval parasitism in this place. The sanitary bearings of this subject are far too important to be dismissed in a summary manner. I have shown that the prevalence or rarity of the beef tapeworm in man is strictly dependent upon the habits of the people; this same cause operating to produce healthy or diseased meat-food, according to the degree of civilisation. In this connection the oft-quoted statements of Kaschin respecting the prevalence of tapeworms among the Burätes, and the well-known frequency of this entozoon in Abyssinia, need only be alluded to.

When discussing the food question in my 'Manual,' I freely availed myself of facts privately communicated by Dr. Joseph Fleming, and I especially referred to the published labours of Lewis, Hewlett, Veale, and other observers stationed in India. Beef measles are extremely common in the cattle of the north-west provinces of India, so much so that severe restrictions have been imposed upon the consumption of ration beef. The presence of a few measles in the flesh of cattle has been deemed a sufficient excuse for condemning and burying entire carcases. The measle is easily distinguished from that of mutton and pork by the fact that its head is not furnished with hooks, whilst in the place of a rostellum there is a small, centrally placed, retractile disk, which assumes the appearance of a supplementary sucker as in the adult worm. The four true suckers are also comparatively large. The measle usually varies in size from the fourth to the half of an inch in length, but my cabinet contains a specimen nearly an inch long. This was contributed by Dr J. Fleming, who mentions having seen

a measle which, when unrolled, measured nearly an inch and a half in length. Although thousands of these bladder worms must exist in the cattle of England, up to the present time not a single instance has been recorded of the occurrence of these cystic parasites in the United Kingdom, except in our experimental animals. Notwithstanding my inquiries, I have not yet found a butcher, flesher, meat-inspector, or veterinarian, who has encountered this parasite in any animal slaughtered for the market. Several butchers have denied their occurrence in meat sold by themselves. Even so late as June, 1874, the presence of measles in the flesh of cattle was denied before an assembly of French *savans*; yet for many years past I have constantly exhibited measly beef and veal in the lecture room of the Royal Veterinary College. (See the discussion of the Société de Thérapeutique, recorded in the 'Bullétin Gén. de Thér.' for June 30th, 1874, and also the 'Jour. de Thér.,' No. 14, for July, p. 556, where, however, special remarks on this head have been omitted; see also the 'Lond. Med. Record' for July 29th, 1874, p. 472, and the 'Lancet' for Dec., 1874, p. 794.) Quite in contrast with the statements referred to are those of recent Italian observers.

Some few years back Professor G. Pellizzari communicated to the Medico-Physical Acadèmy, at Florence, the results of a series of experiments conducted by himself, with the assistance of Dr Tommasi, in regard to the temperature necessary for the destruction of cysticerci in measled meat. An account of these experiments is published in Tommasi's edition of my 'Manual.' The researches were made in relation to certain sanitary measures effected by the Municipal Commission of Florence, the express object of these measures being to prevent the injurious distribution of measly meat, especially that of swine. Signor Bosi, the superintendent of the public slaughter-houses, granted every facility in his power. In a previously published memoir by Professor E. Perroncito it was stated that measly meat (*panicatura degli animali*) required a higher temperature than that of boiling-point for the destruction of the bladder worms in question. In this opinion Signor Bosi shared. According to the original memoir of Perroncito we are told that "about twenty specimens of Cysticerci were collected by the author, and placed in boiling water. After twenty minutes' boiling, not one of the parasites appeared to suffer. The head continued to be drawn into the body, and

when the Cysticerci had their heads drawn out one by one they still appeared to possess all the elasticity of living bladder worms, displaying those movements of extension which are proper to parasites not yet dead. The hooks were observed regularly disposed on the proboscis, where they formed a double crown, the suckers remaining intact." Perroncito remarked, however, that the Cysticerci showed a coloring tendency towards brown, and he added that " with the aid of two needles it became easy to lacerate the body of the Cysticercus, which appeared to be swollen, and possessed of diminished cohesion of its parts." It was evident to all eyes, observed Professor Pellizzari, that these statements involved clear contradictions. Yet again, at page 28 of the memoir, Professor Perroncito wrote :—" During the past winter I introduced some little slices (*fettuccie*) of muscle-flesh (8 to 10 millimètres in thickness), infested with Cysticerci into a vessel (*cassolina*) containing fat at the temperature of 190 to 200° Cent. (374 to 400° Fahr.). At the expiration of ten or fifteen minutes the slices of meat were fried, and the Cysticerci lying at the surface had acquired a light brownish colour, as if they were roasted. By breaking up the slices one could still see the small reddish muscular bundles, whilst the Cysticerci in the middle remained entire and well preserved. Their heads displayed the hooks and suckers regularly distributed." It is certainly singular, as Pellizzari observes, that these Cysticerci, having been thoroughly fried and roasted, should still remain alive and in their normal state; but the ultimate conclusion at which Perroncito arrived was still more startling, and one which, if it were true, would not fail to create a considerable stir among our officers of health. On reviewing the whole matter Perroncito says :—" It appears to me that the melted fat alone of hogs (*maiali grandinosi*) should be utilised, and I am pleased to reckon the illustrious Gerlach and all other distinguished practitioners to be of the same opinion. Permit me, therefore, being well satisfied also with the results of many other experiments, once more to advance the conclusion that, if it is not certain that the Cysticerci die at from 80 to 100° Centigrade (176 to 212° Fahr.), we are quite sure that they dry up and become completely mummified at 125, 130, and 150° Cent. (257, 268, and 302° Fahr.), temperatures which we could easily produce by means of a properly constructed apparatus."

After remarking upon the serious nature of the conclusion

which Perroncito sought to establish, Professor Pellizzari makes further use of quotations which bear upon the question as to whether the quality of the vessels in which the fat of diseased hogs is melted down may not largely affect the degree of high temperature sought to be obtained (in view of a perfect destruction of the Cysticerci). Perroncito repeatedly witnessed the operations of pork-butchers; and when portions of meat were introduced, with water, into the cauldrons, he always saw that the temperature "was maintained between 97° and 98° Centigrade." However, this part of the question may be dismissed in a very few words, since Perroncito himself finally allows that "the different composition of the vessels cannot elevate the temperature of the fat by many degrees."

With the praiseworthy intention of either verifying or refuting these conclusions, Pellizzari, with the approval of Bosi and with the assistance of Tommasi, instituted a fresh series of experiments at a private laboratory. The details of these experiments are exceedingly interesting; but as their record occupies several pages of Tommasi's appendix already referred to, I must content myself with a general statement of the results obtained. Professor Pellizzari found that Cysticerci, so far from requiring a temperature of upwards of 100° Centigrade for their destruction, die at a temperature of 60° Centigrade (140° Fahr.). He had, it appears, previously taken the initiative in recommending certain measures to the Florentine municipality, in view of protecting the public health, and he had now the satisfaction of more than confirming the wisdom of these sanitary precautions. In excessively measled animals the fat is removed and boiled in suitable cauldrons, and has potash mixed with it to render it useful for industrial purposes. By the various measures adopted the entire animal is utilised, and with proper precaution there seems little chance for the measles to arrive at the tænioid or sexually mature condition.

In the next part of his communication Pellizzari touches upon the question of measles in beef, referring especially to the experimental labours of Leuckart and myself. Finding additional support from our views Pellizzari declared the propositions of Dr Perroncito as of no value whatever. "But how is it," he adds, "that notwithstanding that so low a temperature suffices to kill these cysticerci, yet cases of Tænia are continually occurring?" The answer to this question will appear in the sequel; but meanwhile it will be as well to refer to the

recent *brochure* by Dr Giacomini. This author appears to have had no opportunity of perusing Pellizzari's communication already cited, and consequently it is not surprising that he should, in common with others, have accepted the original conclusions of Perroncito. Dr Giacomini clearly perceives that, whatever precautions of a hygienic character are suitable for the prevention of disease arising out of the consumption of measly pork, the same, or at all events similar, measures ought to be adopted with the view of checking tapeworm affections arising from the ingestion of other kinds of meat, especially veal and beef. Like Pellizzari, he is satisfied as to the human origin of the small bladder worms found in cattle, and establishes this position not only from the oft-quoted experiments of Leuckart and Mosler, but also from those conducted by myself and Simonds in England, and by Professor F. Saint-Cyr in France. From a careful review and consideration of all the facts of the case, he recommended a more complete supervision over the flesh of oxen before it is employed commercially, and greater precaution when employing veal as food, by causing it to be subjected to a high temperature, in order that the parasites may be killed before it is ingested. It is evident that Giacomini thinks that a temperature exceeding that of boiling-point is necessary for the destruction of the beef and veal measles, since he immediately adds, "Though experiments have not been made with the object of ascertaining the amount of resistance of heat which the unarmed cysticercus can bear, yet, judging by those conducted by Professor Perroncito on the measle of the hog, we are in a position to say that a temperature of 135° Cent. (275° Fahr.) is necessary for the destruction of an isolated Cysticercus, whilst the heat should be raised from 150° to 200° Cent. (302° to 392° Fahr.) for ten or fifteen minutes, in order to ensure the complete destruction of the Cysticerci encapsuled in the interior of a piece of meat." I have abridged this portion of Giacomini's text, because his statements are pretty much the same as those already quoted from Perroncito (as cited by Tommasi). But, in the next place, Dr Giacomini is in error when he states that experiments had not been performed on the Cysticerci of the ox. So far from this being the case, similar experiments had long previously been conducted by Dr Lewis in India; and these researches had quite as much to do with the measles or Cysticerci of beef as they had with those of the hog, if not more. Naturally but few foreign investigators can

have had access to the work in which Lewis's experiments were originally recorded, and to which, therefore, I must call their attention. Thus, Dr Tommasi has fallen into the error of supposing that the investigations of Lewis were made in England. It is of very little moment where the experiments were carried on, but Tommasi's statement (appendix, loc. cit., p. 161), wherein he says that Pellizzari's experiments, in which he himself took part (*ai quali io stesso ho assistito*), are even more complete than those made in England by Dr Lewis, and in Germany by Dr Küchenmeister, cannot be allowed to pass unchallenged. If Tommasi had enjoyed the opportunity of consulting Lewis's original memoir, he would not have under-estimated our countryman's labors. The memoir by Lewis is singularly complete, and well-nigh exhausts all the facts that can have any interest in relation to the question of public health. Towards the close of his essay he expressly states, as the result of investigation—" (1) That exposure to a temperature of 120° Fahr. for five minutes will not destroy life in Cysticerci, but that they may continue to manifest indications of life for at least two or three days after such exposure; (2) that exposure to a temperature of 125° Fahr. for five minutes does not kill them; but (3) after being subjected to a temperature of 130° Fahr. for five minutes, they may be considered to have perished. After exposure to this and higher temperatures, in no instance have I been able (he adds) to satisfy myself that the slightest movements took place in their substance when examined even under a high power. At least, it may be confidently asserted that, after exposure for five minutes to a temperature of 135° to 140° Fahr., life in these parasites may be considered as absolutely extinct" (p. 139). Thus the statements of Lewis and Pellizzari were in perfect accord; and seeing that their conclusions were alike the result of very careful and independent inquiry, it seemed as if the question at issue was finally solved. These investigations made it perfectly clear that Cysticerci of all kinds, whether found in veal, beef, or pork, could not retain their vitality when exposed to a temperature of 60° Centigrade, or, in other words, 140° Fahr.

The rather severe strictures made on Perroncito's earlier experiments induced the Turin professor to go over the subject more carefully, when he obtained excellent results. He finally ascertained that Cysticerci perished at a temperature below

50° C. (122° Fahr.). In May, 1877, Dr Perroncito furnished me with an account of his researches. With the exception of a few verbal alterations, for which I am responsible, Perroncito wrote as follows :

"In order to resolve the highly important question of the tenacity of life of the Helminths and corresponding larval forms, I made since 1871 a very long series of experiments on the *Cysticercus cellulosæ*, which were published almost at the same time with others of the same kind, made by Dr Lewis in Calcutta. Towards the end of 1874 Mr Pellizzari, of Florence, disputed the results of the investigations which I had made known two years before, *i.e.* in 1872, and agreed with Dr Lewis, who had stated already that the *Cysticercus* exposed to a temperature of 55° C. can be held for dead after five minutes, and also with Dr Cobbold, who thought the temperature of 60° C. quite enough to kill it. But the characters he (Mr Pellizzari) relied upon, needing the exactness and precision required to enlighten and persuade in the most important scientific questions, gave rise to a mistrust in the most scrupulous amongst the men devoted to biological pursuits and to several hygienic measures on the part of the sanitary inspectors with regard to infected pork. Therefore, my conclusions, argued from the experiments made in 1871-72, were still those followed by the most important Italian cities, and approved in principle by the superior Board of Health in 1873. I expressed doubt then about the *Cysticercus* dying at a temperature lower than 100° C., and some person misconstrued these doubts, saying that I had contradicted myself in my work. However, as I could not assert they died at 80°—100° C., I only noticed the alteration of color and cohesion which happened in the *Cysticercus* exposed to various degrees of temperature, to the end that I might contribute usefully to the solution of the difficult question, and concluded that 'if we could not be sure of the *Cysticercus* dying at 80°—100° C., it was certain at all events that they perished at 125° or 130° C.' Not wishing to prejudice the question, I never said that they did not die at 80°—100° C., but simply stated that at this temperature we could not be certain of their death.

"Now, after a large number of experiments, I have been able to ascertain with exactness the lowest degree of temperature required to kill infallibly the *Cysticercus* and other parasites of animals. The means I made use of for this kind of investiga-

tion were Mr Schulze's heating table, the neutral tincture of carmine, the tincture of hæmatoxylon, and breeding experiments.

"My method is founded essentially—

"(*a*) On the fact that the *Cysticercus* when it is fresh and is stretched and conveniently prepared in pure water, or in chloride of soda very much diluted, and afterwards brought gradually from the temperature of the ambient air to that of the body of higher animals and to degrees of heat still more elevated, until life is extinct, keeps moving to and fro with more or less energy throughout its body, using especially its suckers and proboscis.

"(*b*) On the greater imbibing power of the dead tissue generally, which is undoubtedly far more apparent in insects and plathelminths.

"(*c*) On the experiments made to ascertain the value of the two above-stated facts.

"If, after having prepared a *Cysticercus*, newly extracted from a pig in the way we have pointed out, we examine it with a microscope on M. Schulze's heating table, we find that usually it begins to move after 30° or 35° C., and each moment with greater activity, especially after 38°, 40°, 42°, 44°, 45° C. The temperature being raised progressively, we see that the *Cysticercus cellulosæ* puts a stop to its movements occasionally at 45—46° C., seldom at 47° C., more frequently at 48° C., sometimes at 49° C.; and, in fifty and more experiments, only one *Cysticercus* was able to live on beyond 49° C., standing still at 50° C.

"As soon as it stands still the parasite is dead. In fact, if we lower again the temperature gradually to that of the ambient air, and if afterwards we raise it a second time, we pass through all the intermediate temperatures without the *Cysticercus* showing the least signs of life.

"But a more convincing proof of the death of the parasite is got from the greater imbibing power of the tissue when life is extinct, the same over the whole body of the plathelminths, and their larval forms. If we dip the *Cysticercus* alive with its head stretched in the neutral tincture of carmine or hæmatoxylon we can leave it there even two, four, eight, ten, or twelve hours and more, without the head coloring or a real imbibition taking place; this begins only after the *Cysticercus* is dead, so that if the *Cysticercus* is brought first to a temperature hot enough to kill it (with M. Schulze's tables to one of 48°, 49°, 50° C.) and

dipped afterwards in the above-mentioned tinctures, it colors intensely in less than 45°, beginning from the head, and onwards to the extremity of the cyst of the tail. The head colors more intensely and rapidly than the neck, as it is covered with very numerous calcareous corpuscles, which are not met with so frequently in the remaining part of the body.

"*Cysticercus cellulosæ* of the pig, and that of the *Tænia mediocanellata* of the calf, brought gradually to a final temperature, the first of 50° C., and the second of 44°, 45°, and 47° C., and then swallowed alone, or with a piece of butter or crumb of bread, never produced the *Tænia* in the valiant students who voluntarily undertook to make the experiment of swallowing them.

"My investigations were extended to other kinds and forms of Helminths, and the results were always the same, so that, abiding by the same principles, I was able to ascertain that—

"1st. The *Cysticercus cellulosæ* of the pig dies sometimes at 45° C., more frequently at 47° C., ordinarily at 48° C., very seldom reaches alive 49° C., and is quite an exception when it resists for a few moments the temperature of 50° C., so that we can say that the *Cysticercus* brought gradually up to this temperature most assuredly dies if it is kept there longer than one minute.

"2nd. A *Cysticercus cellulosæ,* extracted by Professor Raymond from the conjunctiva of a child's eye, died between 45° and 46° C.

"3rd. The *Cysticercus* of the *Tænia mediocanellata* dies sometimes at 44° C., very often at 45° C., and does not resist a temperature superior to 46° C.

"4th. The *Cysticercus pisiformis* of the rabbit, like the *cellulosæ,* dies sometimes at 45° and 46° C., but generally stands still and perishes at 47° and 48° C.

"5th. A *Cysticercus tenuicollis* died at 49° C.

"6th. The *scolici* of the *Cœnurus cerebralis* of a sheep died at 42° C.

"7th. The *scolices* of the cysts of *Echinococcus polymorphus* die generally between 47° and 48° C., and in no case amongst those I have experimented on did it reach 50° C. alive.

"8th. The *Tænia cucumerina* died, one at 43° C., and a second parasite at 45° C.

"9th. A few individuals of *Tænia serrata* of the dog died at 50° C.

"10th. Two individuals of *Tænia perfoliata* of the horse died, the first at 45° C., the second at 50° C.

"11th. The embryos of the *Filaria microstoma* of the horse began to stand still at 46—47°, and all died at 48° C.

"12th. The embryos of the *Filaria megastoma* of the horse's stomach died at 47° C.

"13th. The *Trichina spiralis*, both free and in a cyst, in several experiments always died at 48° C.

"14th. The embryos of the *Strongylus filaria* of the sheep stood still at 50° C.

"15th. Probstmayer's viviparous oxyurids, the infusoria of the colon and cæcum of the solipeds, and the psorosperms of the liver of the rabbit did not stir at all.

"Each experiment lasted about ten minutes, and the temperature rose from 8—10° C. to 45—46° C. in six to eight minutes; and from 46° to 50° in one minute. These experiments have a great value, both scientific and practical, as they show, on one side, which is the lowest intensity of heat sufficient to kill always the *Cysticercus*, the *Trichina*, and other parasites, reducing thus by far the tenacity of life generally attributed to a large number of Helminths and corresponding larval forms. They assure us, moreover, of the harmlessness of the flesh infected by the above-mentioned parasites, when it is cooked in such a manner as to reach the temperature of 50° C. over all points of the pieces, even though it be kept at such a degree of heat not longer than five minutes.

"In a piece of leg of pork the *Cysticerci* were found alive in all places not yet putrefied twenty-nine days after the animal had been slaughtered. On the other hand, in the dry muscles of a calf the *Cysticerci* of the *Tænia mediocanellata* were all found dead fourteen days after the slaughtering of the animal. I have ascertained that putrefaction of the flesh is fatal for the two larval forms of these different kinds of helminths."

In a subsequent communication received from Professor Perroncito towards the close of the year 1877 he writes:

"At the last meeting, held on April 23rd, I made a statement to the Medical and Surgical Society of Turin, of the results of other experiments tried by heating at M. Schulze's table and by the imbibitions with the neutral tincture of carmine, through which I came to the conclusion that the *Cysticerci* of the *Tænia mediocanellata* die sometimes at 44° C., now and then at 45° C., and always at 46° C. I therefore concluded

that they could in no case survive at 47° C. and 48° C. when they were maintained at this temperature at least five minutes. But to the end of more fully corroborating the facts I had thus communicated, I, contemporaneously with these, made some breeding experiments with the same *Cysticerci* on bold and courageous students who generously offered themselves for the benefit of science.

"Consequently I am now enabled to state that neither Mr Gemelli nor Dr Ragni contracted the *Tænia,* though each of them had eaten a *Cysticercus* of the *Tænia mediocanellata* previously, and respectively subjected to a temperature of 45° C. and 47° C. The larvæ were properly prepared and submitted to gradual heating on the above-mentioned table, and swallowed when they no longer gave signs of life. In like manner no generation of the *Tænia* took place in the body of Mr Martini, who ate the *Cysticercus* brought to a temperature of 44° C. It was maintained at this degree of heat during a period of about three minutes, and swallowed whilst a very slight movement was still visible in a portion of its neck.

"In another student, on the contrary, who ate a living *Cysticercus* of the *Tænia mediocanellata,* the tapeworm reached its maturation in fifty-four days and eliminated the two first proglottides. It threw off two more on the fifty-eighth day, and thirty on the sixtieth. Sixty-seven days after swallowing the *Cysticercus* this courageous young man, having, like his three companions, taken some *kousso* and castor oil, emitted the *strobila.* It was furnished with 866 rings, but destitute of the neck and head. Its measurement afforded a total length of 4·274 mètres.

"Adding now to the 866 proglottides the thirty-four already eliminated, 900 would be the number of the segments; and reckoning the length of each of the latter to be fourteen millimètres, we should have had the *strobila* (deprived of the head and neck) reaching a length of 4·75 mètres. Further, calculating the head and neck to be eight millimètres long, a total length of 4·83 mètres would be the result.

"From all these facts we may conclude that the *Tænia* has, in our instance, reached an approximative length of seventy-two millimètres a day, affording a daily production of 13·43 proglottides."

In relation to requirements of state medicine I have thought Perroncito's researches sufficiently valuable to be quoted at some length; but their chief interest culminates in the worm-

feeding experiments. Excellent in all respects as was the conduct of the medical students who, with Professor Perroncito's approval, swallowed living specimens of the *Cysticercus bovis*, the intentional ingestion of beef measles is by no means a novelty. Eight or ten years back Dr Oliver (after explaining to one of the selected victims the possible consequences of the experiment) induced a Mahommedan syce or groom and a Hindoo boy to swallow perfectly fresh and living beef measles. In this way Dr Oliver successfully reared the *Tænia mediocanellata* in India, and he was thus enabled to fix the amount of time necessary for the full growth of the strobila. Many other persons have diplayed an equal amount of zeal in the cause of helminthology, by partaking of the larvæ or germs of other parasites. Thus, at the risk of repetition, I may state that Möller many years ago swallowed the slender-necked hydatid (*Cysticercus tenuicollis*) in the hope of infesting himself with *Tænia marginata*. Several persons have defiantly swallowed trichinised flesh. Professor Leuckart and some of his pupils also courageously swallowed the eggs of *Oxyurides*, and they had the infinite satisfaction of noticing the young worms in their fæcal discharges some fifteen days afterwards. Dr Crisp ate part of the cooked flesh of an animal that had died of cattle plague, and I myself partook of moderately cooked meat which I knew to be swarming with psorosperms. These obscure organisms were by some persons considered to be either a cause or product of the rinderpest. They will be noticed in my account of the Protozoal parasites.

For the purpose of advancing science and the welfare of the people, there are scores of persons always to be found ready to make personal sacrifices of the kind undertaken by Drs Ragni, Martini, and Gemelli. Unfortunately for English science there are not wanting people in this country who are prepared to threaten with fines and imprisonment any *savant* who may think it desirable to perform a similar set of feeding experiments on animals. Invaluable for good as our experimental investigations have already been, it would seem as if it were the deliberate aim of these sentimental obstructives to put a stop to the acquisition of all useful knowledge in the future.

In reference to the rate of growth of tapeworms, Professor Perroncito's determinations are useful, inasmuch as they verify certain ascertained facts with precision and confirm the general

conclusion that had been drawn by practical helminthologists from various sources of information. In regard to the number of proglottides proper to a sexually mature tapeworm, the circumstance that Perroncito's calculation was made without the head and a portion of the neck of the worm being present shows that it cannot be relied on absolutely; nevertheless, as far as it goes, it tends to confirm what Leuckart had long previously stated. I have possessed myself of upwards of thirty perfect beef tapeworms expelled from my patients, and in some of the specimens it was noticed that the segmentation-rings in the region of the neck were far more crowded together than they were in others. I also possess a perfect *Tænia mediocanellata*, removed post mortem. Though the rate of growth may be the same from day to day, yet experience has shown that the number of proglottides actually cast off varies exceedingly. Küchenmeister's estimate of the average number agrees in the main with what we have ourselves observed (five to twenty daily); and here again Perroncito's investigations serve to verify the general correctness of our previous determinations.

To return to Pellizzari's researches, one of the most important questions is that which relates to the prevalence of tapeworm. In this connection he first brings forward some very interesting and instructive data that had been previously communicated to the Medico-Physical Academy of Florence by Professor Marchi. On the occasion referred to Marchi had stated that, out of thirty-five Tæniæ which he had examined, only one belonged to the species known as *Tænia solium*; all the other thirty-four being of the unarmed type, or *Tænia mediocanellata*. Reflecting on this striking fact, and also on the circumstance that he had in vain begged his colleagues to send him specimens of *Tænia solium*, Marchi seems to have missed the very palpable explanation of this otherwise strange phenomenon. "How does it happen," exclaimed Marchi, "that, notwithstanding the occurrence of 13,000 kilogrammes of the flesh of measled hogs in the public butcheries, I have seen but one specimen of *Tænia solium*, whilst thirty-four cannot have originated from the pig?" "The wherefore is obvious enough," replies Pellizzari, "because our hygienic regulations demand that the flesh of the hogs be raised to a temperature of 60° Cent. (140° Fahr.);" and he then himself immediately proceeds to ask another question, namely, as to how it happens that the *Tænia solium* is so frequently seen in other places. To his own question Pellizzari responds by remarking—

(1) that there are not so many precautions (of a sanitary kind) taken in other places; and (2) that the people elsewhere consume more slightly salted or uncooked meat, as sausages and so forth (*come salame giovane, salciccia e via dicendo*). Pellizzari, having explained that Marchi's thirty-four tapeworms must all have arisen from the consumption of the Cysticercus of the ox, then goes on to speak of the prevalence of tapeworm in Florence, even in little children. This last-named feature, he says, is due to the circumstance that raw meat is frequently employed as a restorative (*come cura ricostituente*). "Thirty years ago," remarks Professor Pellizzari, "it was just as difficult to find a single *Tænia mediocanellata* as it is now easy to find a great number of these worms; and all because it is nowadays customary to eat the flesh of the ox either insufficiently cooked or raw. This absolute inversion of the facts of the case affords proof of the correctness of the position sustained by me, to the effect that the cooking of meat up to the degree of temperature necessary for ebullition ensures the destruction of the Cysticerci." Notwithstanding this statement of his own, Pellizzari thinks that the interference of inspectors may be pushed too far, and thus serve to bring about the very disasters which it should be their supreme object to prevent. Thus, he argues against the suggestions of those who would entirely prevent the sale of measly meat, and who would only permit, as obtains in the province of Modena, the melting down of the fat of hogs. Very strict measures of this sort would, as he says, constitute a radical means of entirely stamping out *Tænia,* but he also very judiciously reminds the sanitarian (*igienista*) that "such a step would be a serious thing for the tradesman, bringing injury not only to the municipal administration, but also proving an encouragement to smuggling. In this way the public health would sustain worse injury by the inducement held out to the owners of infected animals to slaughter them in secret butcheries, thus little by little withdrawing the meat from the superintendence of the public officials. By the adoption of fraudulent measures there would be a daily consumption of diseased meat; and thus also, while the public administration would suffer loss, the public health, on the other hand, would gain nothing." In effect Pellizzari says, if we advise the employment of more severe and radical measures than those already in vogue in Florence, we should overburden the tradesman, almost compel him to

defraud the exchequer by smuggling, and greatly injure the public health.

The facts and explanations advanced by Italian writers regarding the causes of the endemic prevalence of tapeworm, are in perfect harmony with those previously obtained from other sources. Respecting these causes there is much that is both new and interesting. The eighth annual report of the sanitary commissioner of the Government of India had already made us acquainted with the fact that during the year 1869, out of 13,818 head of cattle slaughtered in the stations of the Upper Punjab, 768 beasts were found to be infected with measle-cysts. This, as I have remarked (Tommasi's edit., p. 54), "affords a rate of 5·55 per cent., being a considerable diminution of the proportion observed in 1868, when the percentage gave a total of 6·12. The reduction was, without doubt, due to the vigilance and enlightenment of the army meat inspectors. The prevalence, however, of tapeworm does not bear relation to the number of animals infested with Cysticerci so much as to the actual number of Cysticerci developed in infected animals. I have frequently pointed out the inadvisability of condemning and burying the carcases of measly oxen, whether there be few or many Cysticerci present, and I have stated, on trustworthy evidence, that even the presence of a few Cysticerci is deemed by some inspectors a sufficient reason for rejecting the entire animal. Such a waste should never be allowed. In regard to the numbers of ox-measles present in particular instances, I have elsewhere adduced some remarkable facts communicated to me by Dr Joseph Fleming, of the Indian Army Medical Staff. None of my experimental animals, though fed with scores of ripe proglottides, yielded such an abundance of Cysticerci as Dr Fleming encountered in Punjab cattle. In one pound weight of the psoas muscles Fleming counted no less than 300 Cysticerci." From this it follows that the flesh of a largely infested animal is capable, under the circumstances of ration distribution and imperfect cooking, of originating numerous tapeworms.

Not many years back the leading medical journal of this country challenged me to produce evidence as to the injuriousness of beef and mutton from Cysticerci. The writer stated in his article that I had "failed to produce a single specimen of beef or mutton measles" which had not resulted from experiments conducted "at the Royal Veterinary College;" and he

said, further, "that butchers, fleshers, and veterinarians were practically right in refusing to adopt the opinion of Dr Cobbold, that measled beef or mutton is produced to any great extent" independently. How palpably I endured a species of unjust reproach for being somewhat in advance of the knowledge current at the time may be gathered from the voluminous evidence which has since cropped up from various parts of the world. It was, indeed, mainly through experiments conducted at the Royal Veterinary College, and reported in the 'Lancet,' that professional men in India first became acquainted with the possibility of finding Cysticerci in beef.

The statements of Dr Joseph Fleming, who was one of the foremost in discovering cystic disease in cattle, have since received abundant confirmation. The Indian Government Reports given in the February issue of the 'Madras Monthly Journal of Medical Science' for 1873 are especially instructive. Referring to the prevalence of Cysticercus in the ration beef at Jullundur, in the Punjab, the Inspector General (India Medical Department) reports as follows:

"Cysticercus was first noticed here in the beef tendered at the Royal Artillery ration stand in May, 1868. For some two years previous to this date condemnations of cyst-infected meat had been frequent at Peshawur, Rawul Pindee, Meean Meer and several other stations in the upper part of the Punjab, and here I had often detected the parasite in meat exposed for sale in the bazaars, but no trace of it had been observed in the Commissariat beef, either by myself or any other medical officer who had preceded me.

"From May, 1868, to November, 1869, 'cyst' was more or less frequently found both at the Artillery and 92nd Highlanders' ration stands; but since the latter date it has almost entirely disappeared.

"The following table shows the quantity of meat destroyed on this account during 1868 and 1869:

Years.	Months.	Number of cattle infected.	Weight of meat destroyed.
1868 ...	May	4	412 lbs.
	June	1	77 ,,
	September	1	130 ,,
	October	10	1,763 ,,
	November	14	2,010 ,,
	December	12	1,785 ,,

Years.	Months.		Number of cattle infected.	Weight of meat destroyed.
1869 ...	January	... ...	21	4,062 lbs.
	February	... ...	16	2,341 "
	March	... ...	14	2,209 "
	April	... ...	5	856 "
	May	... ...	2	220 "
	June	... ...	1	122 "
	July	... ...	1	194 "
	August	... ...	3	464 "
	September	... ...	2	218 "
	October	... ...	4	615 "
	Total	...	111	17,478 lbs.

"The whole of this meat was otherwise well fed and of excellent quality. The waste of so much good food led me to make inquiries; 1st, as to the sources from which the cattle obtained the Tænia ova, and the best means for preventing their infection; and 2ndly, as to whether or not any evil results followed the consumption of this meat when properly cooked.

"From information obtained from the Commissariat Officer I found—1st. That the infected cattle had been purchased by native dealers from various parts of the district, not from any particular locality. 2ndly. That when brought in they were lean, and on an average required from two to three months' feeding at the Commissariat cattle yards before they were fit for the shambles. 3rdly. That their food consisted of the grass they could pick up on the grazing grounds of cantonments, supplemented by such an allowance of grain and *bhoosâ* as their condition required.

"They were supposed to be watered at a trough with water drawn from a well, but on closely inquiring as to this, it transpired that they very frequently were taken to a large dirty tank near the yard for their water. The question which occurred to me was, were the cattle infected before their purchase by the Commissariat, or was there anything in their feeding to account for it after purchase? I am inclined to the latter opinion for several reasons, thus :—In the large number of the diseased cattle, the Cysticerci were of remarkably small size; many of them having no capsules, except such as were formed by the surrounding structures, and not being more than $\frac{1}{8}$ to $\frac{1}{4}$ of an inch in diameter. Although the dry food given to the cattle was doubtless good, still much of the water they got during 1868 was probably filthy. The tank pro-

viously referred to was situated close to the huts of the camel drivers. These men are all Mussulmans from Cabul, Peshawur, or thereabouts, and many of them are infected with *Tænia mediocanellata*. Human filth was often to be seen on the banks of the tank, and microscopic examination of mud and stagnant water taken from the margin exhibited *Tænia* ova.

"The conditions above shown must have been eminently favorable to keeping up a constant supply of ova, and the fact that Cysticercus entirely disappeared from amongst the cattle a few months after means had been taken to secure them a good supply of well water, seems to confirm the view that this tank must have been the source of a large amount of, if not all, the infection.

"It has been suggested that Cysticercus can be detected before the animal is killed by an examination of the tongue. In exceptionably severe instances this is probably correct, but then it would be equally observable in some other parts of the body. Major Biggs, Commissariat Officer here, tells me of an animal he saw at Rawul Pindee, in which immense clusters of cysts could be felt at the root of the tongue and under the skin in several parts. After examining a very large number of tongues of 'cysted' animals, my experience is that it is found in the soft muscles and cellular tissues at the root of the tongue, perhaps more frequently than anywhere else; but I have never seen a case in which there was a chance of detecting it before death.

"The most common situations in which it has occurred in the ration meat have been the gluteal, psoas, and lumbar regions. In many instances only from one to ten cysts have been found on cutting the carcase into small pieces, and I have no doubt that it often passed without detection.

"During 1868 and 1869 I from time to time obtained pieces of beef badly infected with *Cysticercus*, and made some experiments as to the results of its consumption under different conditions.

"After explaining to them the possible consequences of eating it, a buttock of beef studded with *Cysticercus* was given to three natives of low caste. They all declared that they were free from *Tænia*, or, to use their own term, "Kadhu dana." The meat they cooked in their own way. These men were under my observation for some six months. Two of them had no symptom of *Tænia*, but the third, who was a low-class

Mahommedan syce, and had probably eaten the meat in a very raw state, developed a *Tænia mediocanellata* in about three months.

"My own sweeper ate this cyst-infected beef regularly two or three times a week for some months. He cooked it well generally as an ordinary stew, and has never shown a sign of having tapeworm.

"Into the food of a boy of low Hindoo caste, but who had never eaten beef, two scolices of Cysticercus were surreptitiously introduced, the result being that, between three or four months afterwards, he applied for some tapeworm medicine."

[The two successful experiments here reported are evidently the same as those that I have referred to (p. 72) as having been performed by Dr Oliver, of the Royal Artillery, stationed at Jullundur. The report continues as follows :]

"*Tænia mediocanellata* is very common amongst the Mussulman population of the Punjab, and from reliable sources I am informed that the lower classes amongst them are in the regular habit of eating half-cooked beef; indeed, prefer it so, and it is amongst these people that tapeworm is so prevalent.

"But it is not only thorough cooking that is required to guard soldiers in India from the ill effects of eating measly meat; there is want of cleanliness in the general arrangements of the kitchens and serving of meals, which must offer great facilities for the introduction into the food of Cysticercus.

"Barrack cooks, unless constantly looked after, are utterly careless as to the washing of chopping blocks, tables, dishes, &c. The dish or pot cover on which the meat is placed when raw is often used without washing for serving the piece up for dinner, and I have myself picked up a *Cysticercus* from the table on which a cook was preparing food. The dangers too of the parasite being conveyed by the cook's unwashed hands to the plates in which meals are served, and the common practice of using the same knife for cutting up meat, and afterwards, without washing it, for other culinary purposes, must not be overlooked. With good selection and careful feeding there seems to be every probability that Cysticercus would soon almost or completely disappear from our Commissariat cattle. If they were entirely stall-fed and watered from wells there could scarcely be a possibility of infection after their purchase.

"Perhaps with the trench system of conservancy, which will necessitate the growing up crops, a sufficient quantity of root and other green produce may be obtained from cantonment lands set apart for this purpose, to supply green fodder for the cattle."

The important question as to whether the presence of cysts detected at the root of the tongue could be made available for the purposes of diagnosis was made the subject of special report through the agency of executive Commissariat officers, and they testified to its practical valuelessness in the following terms :

"*Jullundur.*—No appearance of cyst has been found at the root of the tongues of any of the cattle. A medical officer was asked for assistance in making search for the cysts, but he also found none.

"*Rawul Pindee.*—It is utterly impossible to discriminate before slaughter, from any outward symptoms, cattle that are cyst infected.

"Every endeavour has been made to discover by close and careful scrutiny before slaughter the cyst-infected cattle, but the result has been in no way satisfactory.

"*Sealkote.*—All endeavours to discover any symptoms of the infection by examination of their tongues, while the animals were living, have been unsuccessful.

"*Mooltan.*—The mouth and tongue of a large number of living cattle have been examined before slaughter, but in no single instance has the infection been so detected.

"Dr. Ross's plan of examining the tongues of all animals at time of purchase is not feasible, as they are usually very wild and frightened, and often dangerous to approach.

"*Peshawur.*—In probably 99 cases out of 100 it is utterly impossible to discover cyst infection in cattle previous to slaughter by examination of their tongues. In only one instance has it been so discovered, and that was from the animal's having a number of small lumps over the body which were also apparent on the back part of the tongue. When the tongue is infected the 'cyst' lies so far at the very root of it that it cannot be seen in the live animal."

From Mooltan a specially interesting report was made by Dr Alexander Neill, who says :—

"I have carefully examined the mouth and tongue of a large number of living cattle, and of those slaughtered for issue as

rations, and in no single instance did I find such cysts. These cattle were healthy.

"In a case that died, and in which cysts existed, I could discover nothing abnormal in or under the tongue.

"If such 'cysts' exist, or if such enlargements of the sublingual glands are found, I argue that they are not a diagnostic sign of what is termed 'cyst infection,' or more correctly '*Cysticercus bovis*,' for in the recent outbreak of cattle disease in England, one most prominent symptom of that disease was a bunch of grape-like swelling under the tongue, which in advanced cases suppurated, and to a casual observer would have been called cysts or 'bags of matter.'

"If such swellings are found in a bullock that is sick, it is merely symptomatic of an inflamed condition of the whole mucous surface of the intestinal canal, and not of any localised disease, such as Cysticercus, the above-mentioned swellings being merely inflamed sublingual glands.

"In the pig the diagnostic sign of swellings of the glands or 'cyst' under the tongue is not found in 'Cysticercus,' and the disease called 'measles' is not 'Cysticercus,' but a mere superficial inflammation of the skin and a symptom of fever. '*Cysticercus cellulosus*,' as its name shows, infects the cellular tissue only of the pig, and cannot be discovered in life by any abnormal condition of skin.

"In 'measles' these swellings are found, because intestinal mucous membrane sympathises with eruption on the skin and are then merely inflamed glands, not cysts."

Dr Neill concludes his report by remarking that the larvæ of the beef tapeworm can "only arrive at maturity in the mucous membrane of horned cattle," and not in the cellular tissue. This is an error on Dr Neill's part; but in adducing these instructive extracts from the Government Reports my chief object has been to show the prevalence of Cysticercus in the North-West Provinces of the Indian Peninsula. I may say that a large proportion of my tapeworm-infected patients have been officers from the Punjab, and one of these victims told me that when he superintended the serving out of rations to the troops, "he (and those who acted with him) sent the meat away to be burnt, even when they only detected a single cyst in any given carcase." It is needless to remark that such a waste of valuable food is altogether reprehensible.

Some people, including not a few of the profession, make

light of the occurrence of tapeworm, and I have seen many patients who had been told by their usual medical advisers that the presence of the worms was of little consequence. To account for this wide-spread error there is some basis in the fact that by far the majority of infested persons suffer only the trifling inconvenience arising from the passage *per anum* of the proglottides; moreover, the less civilised the tapeworm-bearers happen to be, the less are they likely to suffer. The recorded experience of Kaschin, before referred to, where 500 hospital patients, in the Baikal district, had tapeworm, although all of them were being treated for other disorders, affords another argument tending to the same conclusion. On the other hand, amongst Europeans only a small percentage of tapeworm-patients suffer severely. But without trenching upon the symptomatology and prognosis of tapeworm disease, I may remark that I have (in my Manual) summarised the the whole facts of cysticercal prevalence within the compass of two brief propositions:—1. The prevalence or the rarity of Cysticerci in cattle in any given country must be determined primarily by the habits of the people; for since the beef measle can only result from the ingestion by the ox of the eggs of the *Tænia mediocanellata*, it is clear that the degree of infection of cattle will correspond with the facilities offered by egg-dispersion. 2. It may be affirmed that the frequency of this particular species of tapeworm amongst the people occupying any given area will bear a strict relation to the amount of underdone measly beef consumed by the inhabitants.

Another question, and one of great interest to sanitary science, is that which I have raised in reference to the period that nature requires for the destruction of the Cysticerci, or, in other words, for the performance of a natural cure by calcareous degeneration of the parasites. I have shown that all kinds of tapeworm larvæ (measles, bladder-worms, cœnuri, and so forth) have a natural life-epoch assigned to them, and in one of my experiments on a Dutch heifer or young cow I demonstrated that a period of ten months was more than sufficient to ensure the perfect destruction of the Cysticerci of cattle. Moreover, this law or process of natural cure is not limited to cestode parasites, but affects all other kinds of internal parasites in one or other of their juvenile stages of growth. In the flesh of my experimental animal I estimated that there were not less than 12,000 of these degenerated Cysticerci. This positive contribu-

tion to our knowledge of the limits assigned by nature to the epoch of larval activity is not merely one of abstract scientific interest, but it has important practical bearings, inasmuch as it points out in what way an entire herd of cattle (known to be measled by the post-mortem examination of one animal previously selected for the purpose, or for that matter, by the rather barbarous act of excising and examining a fragment of the muscle of a living one) may be freed of its parasitic guests; and it also shows how all risk of propagating tapeworm, apart from the question of subjecting the flesh to a certain temperature, may be effectually prevented. The stockowner has but to remove his animals for six or eight months to localities where no fresh infection can occur, when, at the expiration of the time mentioned, all those Cysticerci that existed in the beasts at the time of the transfer will have perished. The flesh of the animals may then be eaten with impunity, whether well cooked or raw. This is an important teaching deducible from experimental inquiry, and I am rather surprised that it has hitherto escaped the notice of persons who, though they affect to ignore the value of scientific researches, are particularly anxious to parade their practical knowledge, which, unhappily, too often proves a mere cloak for ignorance.

The memoir by Giacomini already quoted (p. 65) affords interesting details respecting a case in which there was a most unusual degree of infection of the human body by Cysticerci. Dr Giacomini instituted a searching comparison between the human measles procured by himself and those of the pig sent to him by Professor Perroncito. In the human Cysticerci he noticed a greater adherence of the capsule to the enclosed measle, and he also observed that while the human measle-heads either displayed thirty-two, or in some few cases thirty-four hooks, in two differently sized circles of fifteen or sixteen each, the pig-measles, on the other hand, carried only twenty-four hooks to the double circle of equal circumference; consequently the hooks appeared to be more crowded together in the human parasite. This fact, Giacomini remarks, does not of itself constitute an essential specific difference, since variations of the kind not unfrequently occur in Cysticerci occupying one and the same host. Even the beef-measle is not necessarily confined to one species of host, since Zenker has succeeded in rearing it in a goat.

Although the substance of the above-recorded conclusions

was originally communicated by me, anonymously, to a professional periodical, I have considered this work a suitable medium for a fuller discussion of the subject. Its importance in relation to the public health and the supply of meat-food has not received the attention it deserves.

Bibliography (No. 13.)—*Balert, B.*, 'Die Bandwürmer,' &c. (pamphlet), 1877.—*Bertolus, G.*, 'Diss. sur les metamorph. des cestoïdes,' Montpellier, 1856.—*Cobbold, T. S.*, "On the Production of the so-called 'Acute Cestode Tuberculosis' by the Administration of the Proglottides of *Tænia mediocanellata*" (with Mr Simonds), in 'Proc. of the Royal Society' for May 4th, 1865; repr. in the 'Veterinarian' for 1865, p. 513.—*Idem*, "Experimental Investigations with Cestoid Entozoa," in 'Linn. Soc. Journ.,' vol. ix, p. 170; also for July, 1865, p. 141.—*Idem*, "On Beef, Pork, and Mutton, in relation to Tapeworms," in 'Brit. Assoc. Rep.' for 1865, p. 102, and in 'Appendix to Treatise on Tapeworms and Threadworms,' 1st Edit., 1866, p. 73; also in 'Med. Times and Gaz.' for Sept. 23rd, 1865, p. 343.—*Idem*, "Remarks on Entozoa," in 'Brit. Assoc. Rep.' for 1865, p. 102; also on "Cystic Entozoa from Veal and Mutton," in the 'Path. Soc. Trans.' for 1866, vol. xvii, p. 462.—*Idem*, "Entozoa found in a Westphalian Ham;" report in 'Athenæum' for March 27th, 1869, p. 442; also in 'Brit. Med. Journ.' for March 20th, 1869.—*Idem*, "Note on Beef Measles from a Cow," in 'Path. Soc. Trans.,' vol. xvii, p. 463, 1866; also in the 'Lancet' for Feb. and August, 1865, p. 249.—*Idem*, 'Entozoa,' &c., p. 235 *et seq.*, 1864; and in 'Supp.,' sections iii, iv, v, 1869.—*Idem*, 'Tapeworms,' 3rd Edit. (with 100 cases), 1875, p. 11.—*Idem*, 'Manual of the Internal Par. of Domesticated Animals,' chap. iii to vi, 1874.—*Idem*, 'Worms,' Lectures i to xi, 1872.—*Idem*, "On the Parasites of our Food-producing Ruminants (Cantor Lectures)," in the 'Journ. of the Soc. of Arts,' 1871.—*Idem*, "On the Entozoa of Abyssinia" (Lecture), in 'Lancet,' 1867.—*Idem*, "Remarks on Eighty Cases of Tapeworm," 'Lancet,' June, 1874.—*Idem*, "Revised List of Entozoa, with notes and references (the beef tapeworm, No. 15, and the beef measle, No. 25)," in the 'Veterinarian,' Dec., 1874, and Feb., 1875.—*Idem* (anonymously), "Cysticerci, being a review of the writings of Pellizzari, Tommasi, Perroncito, Lewis, Giacomini, &c.," contributed to the 'Lond. Med. Record,' 1874, p. 642 *et seq.*; repr. in the 'Veterinarian,' Jan., 1875.—*Idem*, "Notice of a Discussion by Paul, Martineau, Créquy,

Delioux de Savignac, Trasbot, and others, respecting the Source and Treatment of Tapeworm," 'Lond. Med. Rec.,' July, 1874, p. 472.—*Idem*, "Review of the Writings of Oliver, Fleming, Hewlett, Lewis, and others, on the Cystic Disease of Animals," 'Lond. Med. Rec.,' June, 1873, p. 339.—*Idem*, "Further Experimental Researches with the Eggs of the Beef Tapeworm," the 'Veterinarian,' Aug., 1875.—*Idem*, "Remarks on Perroncito's Researches," the 'Veterinarian,' Dec., 1877.—*Dardel, A.*, "Sulla frequenza della Tenia in Savoia," 'Giorn. d'Accad. di Med.,' 1868.—*Davaine, C.*, 'Traité' (l. c. Bibl. No. 1), 1860.—*Idem*, "Les Cestoides," in 'Dict. Encyclopédique des Sci. Med.,' 1875.—*Fleming, J.*, 'Indian Med. Gaz.,' 1869.—*Fock, H. C. A. L.*, 'De Lintworm en het middel om hem mit te drijven,' Utrecht, 1873.—*Fritsch, G.*, "Zur differentiellen Diagnose von *T. solium* and *T. mediocanellata*," 'Berliner Klinische Wochenschrift,' 1874.—*Gamgee, J.*, "Entozoa in Veal and Beef" (Letter on), 'Lancet,' 1865.—*Giacomini, C.*, 'Sul *Cyst. cell. hominis* e sull *Tænia med.*, contrib. allo studio dei Cestoidi Parrassiti dell' Uomo,' Torino, 1874.—*Heller, A.*, "Darmschmarotzer," in von Ziemssen's 'Handbuch der speciellen Pathol. und Therapie,' s. 598 *et seq.*, 1876.—*Hewlett*, 'Health Officer's Report,' Bombay, 1870.—*Krabbe, H.*, 'Beretning om 100 Tilfælde af Bœndellorm hos Menesket iagttagne her i Landet (Aftryk af Ugeskrift for Læger),' 1869.—*Küchenmeister, F.*, 'Ueber Cestoden im Allgemeinen und die des Menschen insbesondere, hauptsählich mit Berücksichtigung ihrer Entwickelungsgeschichte, geographischen Verbreitung, Prophylaxe und Abtreibung; specieller Theil. Zittau,' 1853.—*Idem*, 'Parasiten' (l. c. Bibl. No. 1), 1855, Eng. Edit., London, 1857.—*Laboulbène, A.*, "Sur les Tænias," 'Mém. de la Soc. Méd. des Hôpit.,' 1876.—*Idem*, 'Anat. Pathologique,' 1879, p. 962.—*Letheby*, "On Diseased Meat," 'Med. Times and Gaz.,' 1867.—*Leuckart, R.*, 'Die Menschl. Par.,' Bd. i, s. 285 and s. 747, 1864.—*Levi*, "Della freq. della tenia," &c., 'Giorn. Veneto di Scienz. Med.,' 1874.—*Lewis, T. K.*, "A Report on the Bladder Worms found in Beef and Pork" ('App. B. to 8th Ann. Rep. of the Sanit. Commiss. with the Gov. of India'), Calcutta, 1872.—*Masse, E.* et *Pourquier, P.*, "Le Tænia inerme et la lardrerie du Bœuf, Nouvelles Expériences," &c., in 'Montpellier Med. Journ. Mens. de Méd.,' p. 220, 1876.—*Mosler*, 'Helminthogische studien und Beobachtungen,' Berlin, 1864. *Neill, A.*, "Letter, forming the fifth of a series of important articles on Cyst-infected Cattle, and on the prevalence of Cys-

ticercus in Beef," reported by the Inspector General (I. M. D.)," in the 'Madras Monthly Journ. of Med. Sci.,' Feb., 1873; repr. in the 'Veterinarian,' July, 1873.—*Nitsche, H.*, "Untersuchungen ueber den Bau der Tænien," 'Sieb. und Köll. Zeitschrift,' 1873.—*Oliver*, "Rejections of Ration Beef on account of Cystic Disease" (l. c. *supra*), '7th Rep. of the Commiss.,' p. 82, Calcutta, 1871.—*Perroncito E.*, "Della panicatura negli animali," 'Annali della R. Accad. d'Agricolt. di Torino,' vol. xv, 1872.—*Idem*, "Sulla morte del *Cyst. cell.* delle carni del majale;" *ibid.*, 1872.—*Idem*, "Ueber die Lebenszähigkeit des *Cyst. cell.* und anderer Eingeweidewürmer," 'Zeitsch. f. prakt. Veter.-Wissenschaften,' Bern, 1876.—*Idem*, 'Della Grandine o Panicatura nell' Uomo e negli animali,' Torino, 1877.—*Idem*, "Esperimenti sulla produzione del cisticerco nelli carni del bovini, coll' amministrazione di anelli della *tænia med.* dell' uomo," 'Lo Studente Vet.,' Parma, 1876, p. 146.—*Idem*, "Sulla tenacita," &c., *ibid.*, 1877, p. 194.—*Idem*, "Esperimenti sulla prod. del Cyst. della *T. med.* nelle carni dei Vitelli," 'Estr. della Annali d. R. Accad. d'Agric. di Torino,' vol. xx, 1877—*Idem*, "On the Tenacity of Life of the Helminths, and their corresponding Larval Forms in Man and Animals," the 'Veterinarian,' July, 1877, p. 457.—*Idem* (with similar title, including notice of experiments), the 'Veterinarian,' Dec., 1877; partly from 'Osservatore Gaz. d. Cliniche di Torino,' and from 'Archivvo per le Sci. Med.,' vol. i, 1877.—*Idem*, "On the Tenacity of Life of the *Cysticercus* in the flesh of Oxen, and on the rapid development of the corresponding *T. mediocanellata* in the Human Body," the 'Veterinarian,' Dec., 1877, p. 817. —*Probstmayr*, 'Jahrb. der Münchener Thierarzneischule,' 1869. —*Rochard*, "Note sur la fréquence du *Tænia mediocanellata* en Syrie, et sur la présence du cysticerque qui lui donne naissance, dans la chaire musculaire des bœufs de ce pays," in 'Bulletin de l'Acad. de Méd.,' 1877, tom. vi, p. 998.—*Thudichum, J. W. L.*, "On the Parasitic Diseases of Quadrupeds used as Food," 'Privy Council Med. Officer's Rep.' 1865.—*Sommer, F.*, Ueber den Bau und die Entwickelung der Geschlechtsorgane, von *Tænia mediocanellata* und *T. solium*," in 'Siebold and Köll. Zeitschrift,' Bd. xxiv, s. 499, 1874.—*St Cyr*, "Deux Experiences," &c., 'Journ. de l'Anatomie, de Robin,' p. 504; and in 'Lond. Med. Rec.,' by Higgs, vol. i, 582, 1873.—*Tommasi, T.*, 'Appendice (to Cobbold's) Parasiti Interni degli Animali Domestice,' p. 161, Firenze, 1874.—*Van Beneden, P. J.*, "Icono-

graphie des Helminthes ou des vers parasites de l'homme" (Vers Cestoïdes, pl. ii), Louvain, 1860.—*Welch, F. H.*, "Observations on the Anatomy of *Tænia mediocanellata*," 'Quart. Journ. of Microsc. Science,' vol. xv, 1875.—*Zenker*, in 'S. B. Soc.,' Erlang. iv, s. 71.—*Zurn*, 'Zoopathologische und physiol. Untersuchungen,' 1872.

Tænia solium, Linneus.—This cestode was formerly known as the common tapeworm, but in England it is of far less frequent occurrence than the beef tapeworm. In contradistinction it is best to speak of it as the pork tapeworm. Though only one specimen is usually present, the bearer may entertain several worms of this species at one and the same time. The parasite has been known to science from the earliest times, though possibly not earlier than the measles, or Cysticerci, from which it originates. Hippocrates, Pliny, and Aristotle describe the full-grown worm; and, in regard to the larvæ, some have gone so far as to express their belief that the prohibition of swine's flesh as food amongst the Jews and other Oriental people, was dictated by sanitary considerations. Weinland has suggested that the Mosaic commandment not to eat pork may have originated in an old popular notion "of the fact that tapeworm sometimes comes from this food." Weinland's hypothesis is probably correct, for if one supposes Moses to have been supernaturally informed that pork would produce tapeworm disease, one naturally asks why veal and beef should not also have been prohibited, seeing that these meats also frequently harbour tapeworm larvæ.

A perfect pork tapeworm presents itself to the eye of the observer as a long, soft, white, jointed strobile, which, when alive, elongates and contracts itself with facility. Though commonly spoken of as a single creature, it is a compound of many individuals. These are variously called "cucurbitini," "zooids," "proglottides," "segments," "links," or "joints." When fully grown the segments are capable of detaching themselves and of enjoying a free and independent existence. Very annoying it is to the human bearer to be continually reminded of his unwelcome "guests" as they seek to quit his interior.

The head of *Tænia solium* is seldom seen in anatomical museums, although the evacuation of pork tapeworms is not of rare occurrence. Placed under the microscope, the head displays a quantity of dark, almost black, pigment granules, which are abundant at the base of the rostellum and in the

neighbourhood of the hook-fangs. They are equally present and abundant in the pork measle proper, and in measles derived from the human subject. The cephalic hooks of this cestode are comparatively large, those of the greater circle individually measuring $\frac{1}{150}''$, whilst the smaller hooks have a length of about $\frac{1}{220}''$.

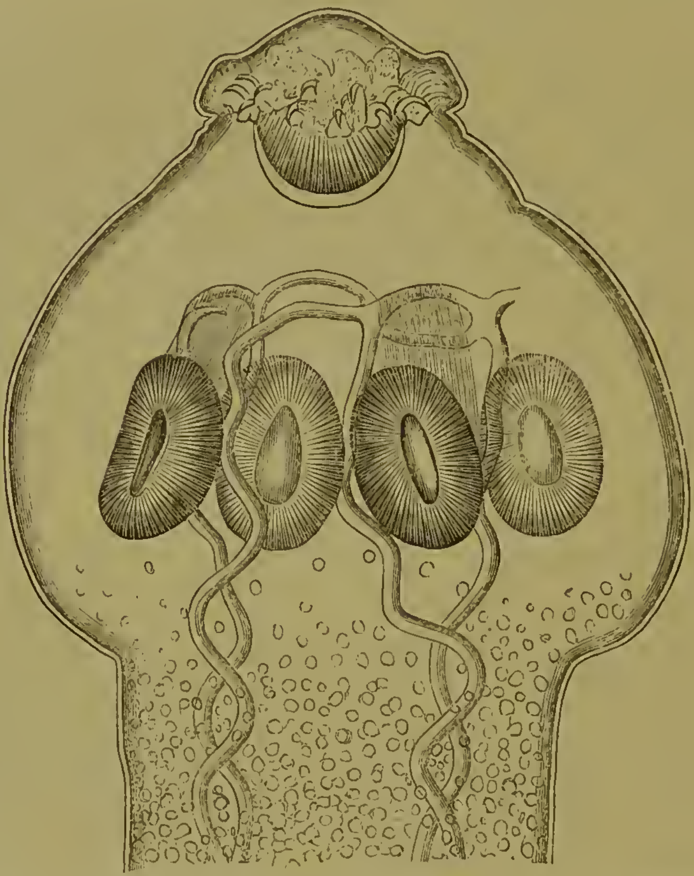

FIG. 23.—Head of *Tænia solium*. Highly magnified. After Van Beneden.

The male reproductive organ consists of a number of small vesicles or sacs, in which filiform spermatozoa have been detected, these latter, when ripe, being conducted by a *vas deferens* into a seminal pouch, from which a canal passes laterally into the penis; the latter organ, in its retracted condition, being lodged within a flask-shaped sheath or cirrhus-pouch. The female organs are somewhat more complicated. They consist of two masses of vitelligene glands occupying a limited space, a small ovarium, a centrally-placed and largely-developed branched uterus, canals of outlet leading from all these organs, and enlargements of the main passages to form internal seminal reservoirs; also, a vaginal canal, which is widened at its termination to form a receptaculum for the curved penis.

In addition to the above-named structures, the entire series of joints from the head downwards are traversed by a set of vascular canals, which are doubled in the region of the head. These form the so-called aquiferous system. There are two main channels, one passing down on either side of the worm, both being connected by transverse vessels, which occur singly at one end of every joint.

The eggs in their mature condition are globular, and contain a six-hooked embryo. They present an average diameter of $\frac{1}{694}$ of an inch, the shell itself measuring about $\frac{1}{4000}''$ in thickness. In 1856 I observed that many of the eggs, whilst still within the uterine branches, displayed an outer envelope, very delicate in structure and totally dissimilar from the egg-shell proper. This has since been more accurately described by Weinland, Van Beneden, and Leuckart. The outer membrane, according to the last-named authority, constitutes the primitive yolk-membrane, within which a part of the yolk-contents separates to form the true egg and embryo by a process of daughter-cell formation. The remaining part of the yolk forms a granular mass, being probably concerned in the formation of the true chitinous shell. The true shell displays a series of radiating and circular lines; the former, however, are more conspicuous than the latter, being due, according to Leuckart, to the presence of a series of fine rod-like chitinous elements, which are formed on the external surface of the original true shell-membrane. The enclosed embryo is furnished with six boring spines, arranged in three pairs, its granular body being invested by an extremely delicate skin-membrane, which is separated from the inner surface of the shell by a clear transparent fluid. The embryo measures $\frac{1}{1250}''$ in diameter.

The scolex or higher larval stage of growth forms the well-known pork measle or *Cysticercus* (*telæ*) *cellulosæ* of authors. The smallest measles found by Leuckart measured $\frac{1}{25}''$ in length. They were obtained from the brain, liver, and intermuscular substance of a pig fed with proglottides about thirty days previously. Only those specimens, however, occurring in the liver at this early period displayed an outer membrane proper to the worm itself, the others being simply invested with capsules formed out of the connective tissues of the host. Many measle-masses in the same host were much larger, presenting an average diameter of $\frac{1}{6}''$. The smallest already displayed a smooth, transparent, homogeneous, outer, cuticular

membrane, overlying a double, finely-granular corium, the latter being traversed by a branched system of aquiferous vessels. These vessels proceed from a central spot, which marks the position of the so-called head-cone, or *receptaculum capitis*. It is, in fact, the first well-marked indication of that flask-shaped capsule within which the head, neck, and body of the Cysticercus is formed, and which Goeze long ago very aptly compared to a lantern. As growth proceeds, a central granular mass forms the true foundation of the head, its upper or stalk-like extension becoming the future neck and body. Further changes result in the evolution of the internal water-vascular system, the calcareous corpuscles, the marginal transverse foldings of the body, the four suckers, the rostellum, and, in particular, the double coronet of hooks. All these metamorphoses were minutely followed and described by Leuckart, who found the development of the larva to be completed within the space of ten weeks.

As regards the injurious effects of this parasite upon man, it may be said to act prejudicially in three separate ways. I have remarked in my 'Entozoa,' that this parasite may cause disease and death both by its action in the larval and adult states. It may likewise injure us by rendering the flesh of swine unwholesome.

When one or more sexually-mature tapeworms have developed themselves within the human intestine, they are apt to give rise to a variety of unpleasant symptoms, more or less marked according to the habit or irritability of the patient. According to Davaine (p. 103 of his 'Traité') the principal features are "vertigo, noises in the ears, impairment of sight, itching of the nose and anus, salivation, dyspepsia and loss of appetite, colic, pains over the epigastrium and in different parts of the abdomen, palpitation, syncope, the sensation of weight in the abdomen, pains and lassitude in the limbs, and emaciation." In ordinary cases there is always more or less anxiety and restlessness; but in severe cases the sympathetic symptoms are very strongly marked, showing themselves in hysterical fits, chorea, epilepsy, and epileptiform seizures, attended by more or less alarming convulsions.

Amongst some of the more interesting and remarkable cases recorded in our English journals, I may instance that of Mr Hutchings, where a complete cure followed the evacuation of the worm which had produced convulsions. Mr Tuffnell records

a case where irritability of the bladder and stricture of the urethra were entirely dependent on tapeworm, as proved by the subsequent recovery. At a meeting of the Pathological Society, in 1853, Dr Winslow mentioned his experience of three or four cases of mania arising from tapeworm ; whilst on the same occasion Drs Ryan and Davey each recorded a similar instance. A case has also been previously published by Mr W. Wood. At a meeting of the London Medical Society, held on the 10th of April, 1837, Dr Theophilus Thomson (during an interesting discussion on this subject) stated the facts of a case where the presence of tapeworm had given rise to a tumultuous action of the heart, this symptom entirely disappearing after evacuation of the worm. Our journals likewise (anonymously) record a considerable number of cases from foreign sources. Thus, in the 'London Medical Gazette' for 1840, there is the case of a lady, aged thirty-seven, who had convulsions attended with a complete loss of consciousness, the separate fits lasting an hour at a time. The passage of the worms effected a complete cure. In the same journal for 1838, there is also the case of a younger lady (aged twenty-seven) suffering from epilepsy, in whom a complete cure had been similarly brought about; here, however, in addition to a single specimen of the *Tænia solium*, there were two lumbrici present. This journal also gives Ettmüller's case, where eighteen tapeworms were the cause of hysteria; and likewise the case published by Steinbeck, where the symptoms presented an altogether peculiar character. More precise references to some of the above cases will be found in the 'Bibliography' below; and I may also refer to my published lectures on Helminthology and especially to my separate work on Tapeworms, where particulars of one hundred cases are briefly recorded. These were all average cases occurring to me whilst in private practice. Davaine's book also abounds with remarkable cases.

Whilst the adult worm is capable of producing serious and even fatal mischief to the bearer, the larvæ or measles much more frequently prove fatal. The Cysticerci may develop themselves in almost any situation in the human body, but they occur most commonly in the subcutaneous, areolar, and intermuscular connective tissue; next, most commonly in the brain and eye, and lastly, in the substance of the heart and other viscera of the trunk.

In my 'Entozoa' I have stated that probably not less than

one hundred cases have been observed where death had resulted from Cysticerci in the brain. Griesinger alone collected between fifty and sixty such cases. Mental disturbance occasioned by the presence of measles in the brain may occur with or without epilepsy. When Griesinger states that "the epilepsy from Cysticercus is in all respects like cerebral epilepsy and the psychical disturbances have nothing characteristic about them," he tacitly admits the impossibility of correct diagnosis during life.

Since the publication of Griesinger's well-known memoir on Cysticerci of the brain, many similar cases have appeared, and amongst the more recent of these is one by Dr Frédet in which the victim was a young man twenty-two years of age. Though apparently in good health he fell dead in the street; the fatal result being due to the presence of a Cysticercus within the *pons Varolii*.

Many other cases of earlier date are especially noteworthy. Thus Mr Toynbee recorded a case where an hydatid (which I take to have been the *Cysticercus cellulosæ*) situated in the middle cerebral fossa beneath the *dura mater*, but in this instance death ensued from other causes. Mr Ottley gives the case of a woman aged forty, where an undoubted Cysticercus in the brain gave rise to distressing fits, convulsions, and death. Then, again, there was Dr Burton's workhouse patient, only twenty years of age, who was found dead in bed, but who at the time of admission merely complained of pain in the head. After death, four hydatids (*Cysticerci*) were found in the *tuber ancillare* at the summit of the spinal marrow. M. Bouvier's similar case is also reported in our periodicals. Of instances where Cysticerci occupied the cavity of the eye, we have one or two cases by Mackenzie of Glasgow, one by Mr Rose of Swaffham, and others by Windsor, Logan, and Estlin. Amongst the more peculiar cases, I may mention that described by Dr Greenhalgh in the 'Lancet' (1848), where the Cysticercus was lodged within the substance of the lip. Five similar cases are likewise recorded by Heller of Stuttgard. Then there is Dupuytren's case of a Cysticercus ensconced within the great peroneus muscle; and also Fournier's, where several of these scolices were said to have been found in a boil. The so-called *Trachelocampylus*, discovered by Frédault in the human brain, was neither more nor less than a common *Cysticercus cellulosæ*.

It is worthy of remark, as Griesinger has also observed, that

in cases where the Cysticerci have taken up their temporary residence in the brain, they are usually found, post mortem, in the grey cortical or peripheral substance of the cerebrum. The particulars of such a case are given in my 'Entozoa' where the victim suffered from epileptic fits due to the presence of numerous Cysticerci (fig. 24). The patient was under Mr Hulke's care.

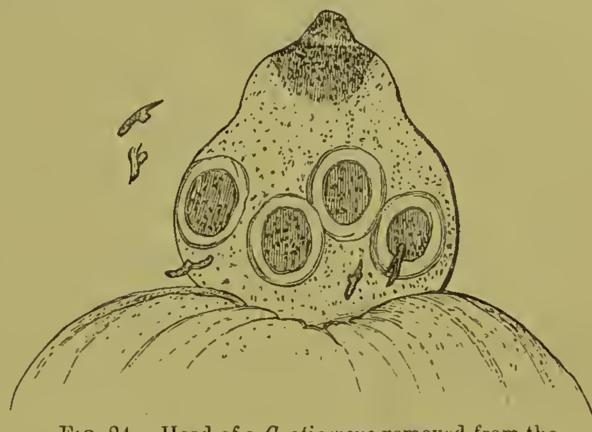

FIG 24.—Head of a *Cysticercus* removed from the brain. Magn. 5 diam. with detached hooks. Original.

As regards infection by the adult worm it is not alone sufficient that we avoid underdone *meat*, as brought to the dinner-table, but we must be especially careful to have our sausages well cooked. Under ordinary circumstances, we are safe for the following reasons:—No respectable butcher will knowingly supply us with pork or with sausages which are measled. Even in the case of underdone meats, in whatever way prepared, it is usually only a small portion which is unaffected by cooking. As we have seen a temperature of 140° Fahr. is sufficient to kill the Cysticerci.

The successful rearing of pork measles by experimentation with the eggs of *T. solium* has been accomplished by many helminthologists, amongst whom may be particularised Van Beneden, Leuckart, Küchenmeister, Haubner, Gerlach, and Baillet. The converse experiment of rearing the adult worm from the Cysticercus was first successfully undertaken by Küchenmeister on a condemned criminal; Leuckart, Humbert, and others having repeated this method with more or less success.

The dangers arising from infection by swallowing the larval worms or six-hooked embryos are not easily avoided. Our flesh, like pork, thus becomes measled, although certainly not to the spawn-like extent so often seen in the lower animals. A single measle is sufficient to prove fatal; and this humiliating contingency, moreover, is one which we can never be absolutely certain of avoiding. We become the "host" or bearer of the measle by swallowing the fully-developed eggs of the *Tænia solium*. This we may do directly by handling fresh tapeworms, whose eggs, being concealed under our

nails or in our clothing, may subsequently be swallowed, and develop within us accordingly. Even a thorough washing of the hands will not ensure absolute security. In like manner, those who partake of choice salads, prepared from the stores of the market-gardener, run a certain amount of risk. The vegetables may have been manured with night-soil containing myriads of tapeworm eggs, or they may have been watered with fluid filth into which the eggs were accidentally cast. In such cases, one or more tapeworm ova will be transferred to the digestive organs, unless the vegetables have been very carefully cleansed. In the same way, one perceives how fallen fruits all sorts of edible plants, as well as pond, canal, and even river water procured from the neighbourhood of human habitations, are liable to harbour embryos capable of gaining entrance to the human body. One individual suffering from tapeworm may infect a whole neighbourhood by rendering the swine measly, these animals, in their turn, spreading the disease far and wide. As already remarked, measles sometimes occur in great numbers in different parts of the body. Among the more remarkable cases of the multiple Cysticerci are those recorded by Delore (1864) and Giacomini (1874). In M. Delore's case, about 2000 were obtained post mortem. Of these, 111 occurred in connection with the nervous centres, eighty-four being in the cerebrum, twenty-two in the membranes of the brain, four in the cerebellum, and one within the substance of the medulla oblongata. Dr Knox published a less notable instance in the 'Lancet' (1838); and in the year 1857, Dr Hodges, of Boston, U.S., published a case where the cysts, which in size he compared to rice grains and coffee beans, were felt subcutaneously. The coexistence of Tænia and Cysticerci in the same individual has also recently been observed in France ('Lond. Med. Rec.,' 1875). Besides these, several remarkable instances have lately been reported by Davy, Tartivel, and others.

To the literature already quoted in connection with the beef tapeworm the following may be added :

Bibliography (No. 14).—*Aran*, in 'Archives Gén. de Médecine,' 1841. — *Baillet*, "Helminthes," art. in 'Bouley and Reynal's Dict. Vétérin.,' tom. viii, 1869.—*Bécoulet* and *Giraud*, "On Cysticercus in the Brain," 'Bullet. de la Soc. Méd. de Gand,' 1872; and in 'Lond. Med. Rec.,' Feb., 1873.—*Birkett, J.*, Cases, 'Guy's Hosp. Rep.,' 1860.—*Bouchut*, "Cyst. in the Brain,"

'Gaz. des Hôp.,' 1857, and 'Journ. für Kinderkrankheit.,' 1859.—*Bouvier*, 'Bullet. de l'Acad.,' 1840.—*Burton*, in 'Med. Times and Gaz.' (supposed hydatids), 1862.—*Cobbold*, "On Measly Meat and Measles in Man," the 'Veterinarian,' 1876.—*Czermack*, "Cysticerci causing Insanity," Corresp.—Blatt, 1838.—*Dalton, J. C.*, "Cyst in the Scrotum," 'New York Journ. of Med.,' 1857.—*Davaine* (see his 'Traité' for many additional references; p. 676).—*Davy, R.*, "Cysticerci in the Muscles," 'Rep. of Lond. Med. Soc.,' 'Lancet' for Nov., 1876.—*Estling*, "Cases of Cysticercus," 'Lond. Med. Gaz.,' 1838-39.—*Frédet*, "Cysticercus in the *pons Varolii*," in the 'Lancet' for June 23rd, 1877 (p. 925), from 'Giornale Veneto de Scienze.'—*Fournier*, 'Journ. des Connois. Med. Chir.,' 1840.—*Griesinger*, "On Cysticerci of the Brain," from 'Med. Jahrb.' in 'Med.-Chir. Review,' 1863.—*Harley, J.*, "Cyst. in the Brain," 'Lancet,' 1867.—*Hodges, R. M.*, "Specimens of *Cyst. cell.*, felt as small tumours just beneath the skin, varying in size from that of a grain of rice to that of a coffee bean," 'Rep. of Boston Soc. for Med. Improvement,' in 'Brit. Med. and Surg. Journ.,' 1857.—*Hogg, J.*, "Obs. on Cysticercus," in his 'Manual of Ophth. Surgery,' 3rd edit., 1863.—*Holler, A.*, "Cyst. cell., im Gehirne einer Geisteskranken," 'Allgem. Wiener Med. Zeitung,' 1878.—*Logan, R.*, "Probable Cases of *Cyst. cell.*," removed by Robertson, 'Ed. Med. and Surg. Journ.,' 1833.—*Mackenzie, W.*, "Cyst in the Eye," 'Lancet,' 1848, 'Lond. Med. Gaz.,' 1833.—*Mazotti, L.*, "Caso di numerosi cisticerchi del cervello e delle meningi," 'Rivista Clin. di Bologna,' 1876.—*Mégnin, P.*, "La Ladrerie du porc et le *Tænia solium*," 'La France Médicale,' 1876.—*Putz, H.*, "Ueber die Lebenszähigkeit des *Cysticercus cellulosæ*," &c., 'Zeitsch. f. pr. Vet. - Wissenschaften,' 1876.—*Rainey, G.*, "On the Structure, &c., of *Cyst. cell.*," 'Phil. Trans.,' 1857.—*Rizzetti, G.*, "Rendiconto Statistico dell' ufficio d'igiene di Torino per l' Anno 1873.'—*Rudall, J. T.*, "Cyst. in the Brain," 'Australian Med. Journ.,' 1859.— *Tartivel, De A.*, "Cysticerques multiples dans le tissu cellulaire sous-cutané et dans certain viscères," 'Rec. de Méd. Vet.,' 1876.—*Von Gräfe, A.*, in 'Arch. für Ophthal.,' 1857.—*Wells, S.*, Bourman's Case, 'Ophth. Hosp. Rep.,' 1860.—*Windsor, J.*, "Cyst. in the Eye," 'Brit Med. Journ.,' 1861.

Tænia tenella, Cobbold.—I have long been acquainted with the fact that there is a comparatively small human tapeworm which cannot be referred to either of the foregoing species. In

the absence of experimental proof, I incline to the belief that the worm in question owes its existence to measly mutton. The sheep harbours an armed Cysticercus (*C. ovis*), which I regard as the scolex of *Tænia tenella*. The specific name (*tenella*) was originally applied by Pruner to a cestode six feet in length, which he found associated with a larger tapeworm. This latter he called *Tænia lata*. Whilst Diesing has pronounced Pruner's *Tænia lata* to have been a *T. mediocanellata*, I, on the other hand, consider Pruner's *T. tenella* to have been a *T. solium*. Mr J. C. Mayrhofer has suggested its identity with *Bothriocephalus tropicus*. When, some years back, I applied the term *T. tenella* to a new tapeworm (of which I possess several strobiles) I was quite unaware than any similar nomenclature had been adopted by Pruner. From the few facts supplied by Pruner and Diesing, I cannot suppose that our cestodes are identical. Unfortunately my specimens are imperfect, wanting the so-called head. It is not possible to estimate the length of the worm accurately, but the perfect strobile must measure several feet.

On one slide I have mounted nine mature proglottides of a worm which I procured on the 15th Dec., 1875. The segments measure, on the average, exactly $\frac{3}{10}''$ in length, and only $\frac{3}{20}''$ in breadth. The uterine rosettes are all full of eggs, and their branches so crowded together that I am unable to ascertain their average number. The segments are perfectly uniform in character, their reproductive papillæ alternating irregularly at the margin.

In the autumn of 1872 I caused a lamb to be fed with the proglottides of a tapeworm which I referred to this species. The animal was slaughtered on the 22nd of January, 1873, when the result was stated to have been negative. As I had no opportunity of examining the carcase, I cannot feel quite sure that there actually were no Cysticerci present. On several occasions I have detected measles in the flesh of animals, when none were supposed to be present by those who either assisted me or were professional on-lookers. Assuming my *Tænia tenella* to be derived from the sheep's Cysticercus, I think it fitting to describe the mutton measle in this place. Even if *T. tenella* be not actually the adult representative of the mutton measle (*Cyst. ovis*), it is quite certain that the scolex in question gives rise to an armed tapeworm, and it is almost equally certain that the adult armed cestode resides in man. In Pruner's case,

which is by no means unique, we have seen that two distinct species of cestode may coexist in the human bearer. It is quite possible that some one may yet have the good fortune to detect the beef tapeworm, the pork tapeworm, and the mutton tapeworm, all together in one and the same host.

On five separate occasions I have detected measles in "joints" of otherwise excellent and healthy mutton brought to my own table, and supplied by the family butcher. On several other occasions I have had these parasites brought under my notice; nevertheless, many persons are either unaware of, or actually deny, the existence of these ovine parasites. Thus, MM. Masse and Pourquier, in the 'Montpellier Med. Journ.' for Sept., 1876, make the following statement: "The sheep, not being subject to measles, it seems to us natural to employ the raw meat of that animal whenever it is required for nourishment in the treatment of diarrhœa, in weaning children, in phthisis, and for anæmics." Clearly, if MM. Masse and Pourquier could have brought themselves to believe that English literature is worth consulting on such matters, they would not have made this statement. Incidently they also observe, when speaking of beef measles:—"Un fait que nous avons remarqué et que nous tenons à signaler, c'est que nous avons trouvé des cysticerques nageant librement dans l'eau où nous avions plongé de la viande infestée de ladrerie." Certainly this is a novel experience. That measles should not only get out of their cysts, but should have the power of "swimming freely" in the water is a phenomenon which requires explanation. There must have been some error of observation.

It was in the year 1865 that I discovered the mutton measle (*C. ovis*, mihi); but I am not prepared to say that the parasite had never been seen before, since it is alleged that a two-headed Cysticercus was obtained by Fromage from the liver of a sheep (as cited by Davaine). Be that as it may, my discovery was announced in a communication made at the Birmingham meeting of the British Association in the autumn of 1865, and subsequently at a meeting of the Pathological Society of London, on the 3rd of April, 1866 ('Path. Trans.,' vol. xviii, p. 463). After these dates further announcements and verifications appeared, amongst which I can only refer to my remarks "On Beef, Pork, and Mutton, in relation to Tapeworms," forming an appendix to the first edition of my work on Tapeworms, 1866; to the "Remarks on Cysticerci from

Mutton," contained in the fourth chapter of the Supplement to my introductory treatise on Entozoa, where a figure of the parasite is given, 1869, p. 27; to Dr Maddox's paper "On an Entozoon with Ova, found encysted in the Muscles of a Sheep," recorded in 'Nature,' May 15th, 1873, p. 59; to the 'Monthly Microscopical Journal,' June, 1873, p. 245; to my further communications in the 'Lond. Med. Record,' Aug. 6th, 1873; to my 'Manual,' 1874, pp. 74 and 105, Ital. edit. 'Nota Dell' Autore,' p. 133; and especially to the article headed "The Mutton Tapeworm," contained in the 3rd edit. of my little volume on 'Tapeworms,' p. 12, et seq., 1875.

In regard to the measle itself, I spoke of it as smaller than the common pork measle. The head is $\frac{1}{30}''$ in breadth, and is armed with a double crown of hooks, twenty-six in all, the larger hooks each measuring $\frac{1}{160}''$ in length. The suckers are four in number, each having a breadth of $\frac{1}{100}''$. The neck and head are abundantly supplied with calcareous corpuscles, being at the same time marked by transverse rugæ. The data on which I founded my brief description of the scolex were chiefly based on the examination of a specimen which had been procured by Prof. Heisch from the interior of a mutton chop. Subsequently much fuller details of the structure of the scolex were supplied by the illustrated memoir of Dr Maddox (above quoted). This excellent microscopist, however, announced the presence of immature ova within the Cysticerci themselves. As the notion of the existence of eggs in larval cestodes was altogether at variance with what we know of the phenomena of tapeworm life, I suggested that the author might have mistaken the egg-shaped calcareous corpuscles (which I found so abundant in my own specimens) for the ova. In the interests of truth I felt bound to characterise certain of the conclusions arrived at by Dr Maddox as simply incredible, but I regarded his memoir as forming "an important contribution to our knowledge of the structure of the mutton measle." I had no idea that in pointing to errors of interpretation I should offend the excellent author. However, a long letter appeared in the 'London Medical Record,' in which Dr Maddox showed that he was much vexed that I should have "impugned" the "accuracy of his conclusions." He defended his position with the support of no less an authority than Dr Macdonald, F.R.S., the distinguished Assistant Professor of Naval Hygiène at the Victoria Hospital, Netley. Dr Maddox says:—"We were quito alivo to the anomalous posi-

tion. Hence the exceptionability of the case rests on more than my own evidence." In regard to this unfortunate dispute I will only add the expression of my conviction that Drs Maddox and Macdonald will eventually become satisfied that no cestode scolex is capable of displaying either mature or immature ova in its interior.

Bibliography (No. 15). *Cobbold* (l. c., *supra*), 1865-75.—*Idem*, "On Measly Meat, &c.," the 'Veterinarian,' Dec., 1876.—*Idem*, "The Mutton Tapeworm (*T. tenella*)," No. 16 in my revised list of Entozoa, the 'Veterinarian,' Dec., 1874.—*Diesing, C. M.* (*Tænia tenella*, Pruner nec Pallas), in "Revis der Cephalocotyleen," 'Sitzungsb. der Math.-Mat. Class d. k. Akad. der Wissenschaften,' Bd. xlix, s. 369, 1864.—*Maddox* (l. c., *supra*), 1873.—*Mayrhofer, J. C.*, 'Die helminth. des Menschen,' Erlangen, 1854. — *Pruner*, 'Krankheiten des Orients,' s. 245, 1847.

Tænia lophosoma, Cobbold.—This is a good species notwithstanding the doubts that have been expressed by Heller and others regarding it. I have called it the ridged tapeworm in consequence of the presence of an elevated line coursing the whole length of the body, which measures about eight feet. The reproductive papillæ are remarkably prominent and uniserially disposed throughout the entire chain of proglottides. It is quite an error to suppose that this species is a malformed cestode, or that it has any resemblance to Küchenmeister's variety of tapeworm from the Cape of Good Hope. Neither does it in the slightest degree resemble the remarkably malformed *T. mediocanellata* described by Mr Cullingworth. Of the distinctiveness of this parasite as a species, any one may satisfy himself by an inspection of the nearly complete strobile preserved in the Pathological Museum attached to the Middlesex Hospital Medical College. From the examination of several mature proglottides detached from this specimen, I find their average breadth to be one fifth of an inch, by three quarters of an inch in length. Their greatest thickness does not exceed the $\frac{1}{13}$th of an inch. The eggs resemble those of other tapeworms, and offer a diameter of about $\frac{1}{850}''$ from pole to pole.

Bibliography (No. 16).—*Cobbold*, "Parasites of Man," in the 'Midland Naturalist,' April, 1878, p. 98.—*Idem*, 'Tapeworms,' 1st edit., p. 52, 1866; 3rd edit., p. 27, 1875.—*Cullingworth* (see Bibl. No. 18).—*Davaine*, 'Les Cestoïdes,' l. c., p. 573.—*Heller*, l. c., s. 594.

Tænia nana, Siebold.—As regards the dwarf tapeworm, unless Spooner's case be genuine, there is but one solitary instance on record of its occurrence in the human body; moreover, we have no evidence of its having existed in any other host. It was discovered by Dr Bilharz, of Cairo, at the post-mortem examination of a boy who died from inflammation of the cerebral membranes. Prodigious numbers existed. The largest specimen measured only one inch in length. To the naked eye these worms resemble short threads, and consequently they might very readily be overlooked. The head is broad and furnished with a formidable rostellum armed with a crown of hooks. These hooks have large anterior root-processes, which, extending unusually forward, impart to the individual hooks a bifid character. By far the best account of this worm is furnished by Leuckart, to whom I am indebted for a specimen.

BIBLIOGRAPHY (No. 17).—*Cobbold*, 'Entozoa,' p. 244.—*Davaine* (l. c., Bibl. No. 2), p. 574.—*Heller*, l. c., s. 606.—*Küchenmeister*, l. c., Eng. edit., p. 141.—*Leuckart*, l. c., Bd. i, s. 393.—*Von Siebold* and *Bilharz*, in Von Sieb. and Köll. Zeitschr., Bd. iv.—*Spooner*, 'Amer. Journ. Med. Sci.,' 1873.—*Van Beneden*, 'Iconographie,' l. c., pl. iii, fig. 17.—*Weinland*, '*Diplacanthus nanus*,' l. c., p. 85.

Tænia Madagascariensis, Davaine.—This appears to be a well-defined species although the head has not yet been seen. It probably forms the type of a distinct genus. Dr Grenet, stationed at Mayotte (Comores), twice encountered single specimens passed by two young children, eighteen and twenty-four months of age respectively. The proglottides have their genital pores uniserially arranged, and they show, in their interior, remarkable egg-capsules, from 120 to 150 in number in all, each containing from 300 to 400 eggs. These give a long diameter of $\frac{1}{625}''$ for the outer envelope and $\frac{1}{1250}''$ for the inner, or shell proper. The embryo measures only the $\frac{1}{2500}$ of an inch. A full account of this parasite, with figures, is given by Davaine ('Les Cestoïdes,' l. c., Bibl. No. 2, p. 577 *et seq.*).

Tænia marginata, Batsch.—Although I possess no certain evidence of the occurrence of this parasite in its adult condition in the human bearer, yet there is a tapeworm in the Edinburgh Anatomical Museum referable to this species, which was said to have been obtained from the human body. This worm is very common in the dog.

The principal evidence demonstrating the occurrence of the larval representative of this species (*Cysticercus tenuicollis*) in man, rests upon the two cases recorded in Schleissner's 'Nosography' of Iceland. One of the alleged instances, however, has been proved by Küchenmeister and Krabbe to be that of an echinococcus; so that, after all, there only remains the solitary case observed by Schleissner himself, in which the parasite can fairly be considered as the "slender-necked hydatid."

To the above, however, may probably be added a specimen preserved in the Anatomical Collection at King's College, London. It was found connected with an ovarian cyst.

Tænia elliptica, Batsch.—This parasite is readily recognised not merely by its delicate form and small size, but also by the circumstance of its supporting two sets of reproductive organs in each mature joint. Their outlets are situated at the centre of the margin of each segment, one on either side. Ordinarily infesting the cat, this worm is a mere variety of the common *Tænia cucumerina* of the dog. At all events, from the evidence put forth by Eschricht, seconded by Leuckart, there is every reason for believing that one or other of these closely-allied varieties is liable to infest the human body. It was originally stated by Eschricht that he had received a *Tænia canina* which had been passed by a negro slave at St Thomas, Antilles. This is a synonym of *T. elliptica*, which must therefore be very rare in the human body, possibly only occurring in the negro race.

In regard to the source of this parasite, it has been shown by Melnikow that the scolex of *Tænia cucumerina* resides in the louse of the dog (*Trichodectes latus*), and thus it is exceedingly probable that the scolex of *Tænia elliptica* resides in the louse of the cat (*Trich. subrostratus*). How man becomes infested is not so clear. Melnikow's paper on the juvenile state of this cestode is contained in the 'Archiv für Naturgeschichte' for 1869, and is illustrated by a figure of the measle.

Tænia flavopuncta, Weinland.—Regarded as a new species, the discovery of this little tapeworm is due to the investigations of Weinland. In Dr Jackson's 'Catalogue of the Boston Medical Improvement Society' an account of the contents of a phial is recorded as follows:—"Specimen of Bothriocephalus, three feet in length, and from half a line to one line and a quarter in width, from an infant. The joints are very regular, except at one extremity, where they approach the triangular form, are very delicate, and but slightly connected, as shown in

a drawing by Dr Wyman." It is further stated that the infant was nineteen months old, and that the worm was discharged without medicine, its presence having never been suspected. It was presented by Dr Ezra Palmer in the year 1842. On examining the fragments, Dr Weinland found, instead of a solitary specimen, at least six different tapeworms, all of them being referable to a hitherto undescribed species. There were no heads; nevertheless, it was ascertained that the worms varied from eight to twelve inches in length, the joints or segments being very broad, and at the same time narrowed from above downwards. The parasite was named "the spotted tapeworm," in consequence of the presence of yellow spots near the middle of the joint. They represent the male organs of reproduction, the outlets of which, as in my *T. lophosoma,* occur all along one side of the body or strobile. In Weinland's estimation this parasite forms the type of a new genus which he calls *Hymenolepis.* A full account of the worm is given in his well-known essay (l. c., Bibl. No. 2).

Tænia abietina and other varieties. I can only notice very briefly certain cestodes which either present malformations or which may be regarded as mere *varieties.* First in this series is Weinland's *T. abietina.* No one who has studied his 'Beschreibung zweier neuer Tænioiden aus dem Menschen,' Jena, 1861, can doubt that it is a mere variety of *T. mediocanellata.* The monstrosity described by him as referable to *T. solium* must also be referred to the beef tapeworm. The variations in the character of cestode proglottides is practically infinite. A museum might be filled with them. Most common with *T. mediocanellata,* these varieties more or less prevail with other species. Thus I have seen them in Tæniæ and Bothriocephali alike. I have obtained segments of *T. mediocanellata* having sexual outlets on both sides of the proglottis, so regularly disposed in a few segments as to suggest the notion of a new species. The coalescence of several segments into one compound segment is frequent, but the most remarkable specimen that I have seen is one contained in the museum of the Royal College of Surgeons. In the old Hunterian catalogue the specimen is described as "two joints of the *Tænia solium,* with a number of orifices in unequal series on either side." As stated in the new catalogue of the series, prepared by myself, the "lower segment is furnished with twenty-two sexual orifices, one of which is situated in the central line" on the ventral surface (as in Bothriocephali).

References to this and other specimens in the Hunterian Collection will be found below (see *Pittard*). In regard to Weinland's conjectural *Tœnia acanthotrias*, based on the circumstance of his having found a Cysticercus that presented three rows of hooks on its rostellum, I need only say that if such a *Tœnia* were found it would only turn out to be a malformed *T. solium*. The specimens, however, are none the less interesting. Very remarkable and altogether exceptional characters are presented by the strobile of the cestode described by Mr Cullingworth, of Manchester, and of which I possess specimens. Here, apparently, at least two tapeworms are joined together throughout the entire chain of proglottides without intermission. The three margins of each compound segment project at equi-distant angles. Could we have secured the head we should certainly have found six or eight suckers present, since the finest neck-segments showed that the malformation pervaded the entire colony of zooids, sexually mature and otherwise. Mr Cullingworth's specimen is so remarkable that I subscribe full particulars of the case in his own words. He says:—" A respectable married woman, named Ann H—, forty years of age, residing in Salford, brought to my out-patient room at St Mary's Hospital, Manchester, on September 3rd, 1873, a few segments of tapeworm as a sample of what she had been passing per anum for about two years. Although never in the habit of taking meat absolutely raw, she told me, on inquiry, that she was particularly fond of tasting it when only partially cooked. The segments were unlike anything I had seen before, and I took them home for examination, ordering the patient meanwhile a draught containing a drachm of the oil of male fern, and giving her strict injunctions to bring to me every fragment that passed away as a result.

" On September 17th she brought me portions of a tapeworm corresponding throughout to the segments I had already seen, and measuring altogether nine feet in length. Unfortunately, the head was not to be found. Along the middle line of every segment in the body a crest or ridge runs longitudinally, and in the centre of the margin of this crest the genital pore is situated. [In 304 segments examined, only four had the genital opening placed laterally. One segment had two openings, viz. one at the lateral margin and the other in the crest.] Underneath the segment there is a longitudinal groove, and the lateral portions are folded together by the apposition of their

under surfaces. When hardened in spirit the section of a segment presents a three-branched appearance, the branches being of unequal length, but placed at equal angles. The uterus sends vessels into the crest as well as into the sides of the segment; and the contained ova are exactly like the ova of an ordinary *Tænia mediocanellata.* Wedged in between, or attached to, the segments here and there, is a stunted and ill-shaped joint, with irregular and unequal sides. A mature joint measures from five eighths of an inch to three quarters of an inch in length, and about half an inch in breadth, and the breadth or depth of the crest is usually one eighth of an inch.

"There are only two specimens that I can find on record at all similar to the one here described, and both of these differ from it in several important particulars. Küchenmeister mentions, as a variety of *Tænia mediocanellata,* a tapeworm sent to him from the Cape of Good Hope by Dr Rose. This worm possessed a longitudinal ridge, but he describes its mature segments as 'extremely massive'—more than an inch in length and $\frac{3}{5}''$ in breadth. The genital pores, too, were irregularly alternate, and not situated on the crest. On March 20th, 1866, Dr Cobbold exhibited to the Pathological Society of London a specimen of crested tapeworm which was discovered in the museum of Middlesex Hospital, and to which he proposed to give the name *Tænia lophosoma* (λόφος, crest; σῶμα, body). The reproductive papillæ were all on one side of the chain of segments, a peculiarity which entirely distinguished it from the Cape of Good Hope variety of Küchenmeister. The head of the creature was wanting. It will thus be seen that my specimen does not correspond with either of these in the situation of the genital aperture. Here it is placed in the crest itself, and not unilaterally, as in Dr Cobbold's specimen, or alternately, as in Küchenmeister's. It further differs from the Cape variety in the more moderate dimensions of its proglottides. I have adopted, however, the name suggested by Dr Cobbold in the communication referred to, inasmuch as it sufficiently indicates the principal distinguishing feature of the specimen. I may mention that Dr Cobbold saw the specimen during his visit to Manchester, and that he regarded it as a most remarkable and unique abnormality."

Further, in connection with abnormal cestodes, I may observe that Weinland's case of a triple-crowned Cysticercus does not

stand alone, since a similar specimen is, I believe, in the possession of the Rev. W. Dallinger. This was removed from the human brain. Curious as this subject is, I cannot dwell upon it. Not only are the mature tapeworms and their Cysticerci liable to present monstrosities, but even also their proscolices or six-hooked embryos. Thus, twelve hooks were observed by Salzmann in the embryo of *T. elliptica*, and Heller also figures two embryos of *T. mediocanellata* (*T. saginata*, Gœze) with numerous hooklets. Dujardin saw seven in a *Bothriocephalus* embryo. Occasionally there have been errors of interpretation made by observers. Thus, Diesing has given beautiful figures of *Dibothrium hians* in such a way as to suggest different degrees of monstrosity affecting the tail end of the strobile; but this splitting has clearly resulted from injury. Thus also, when I removed five specimens of a new cestode (*Diphyllobothrium stemmacephalum*) from the intestines of a porpoise, one of them was cleft nearly half way up the strobile. This had been done by the scissors employed in slitting up the gut; but owing to perfect contraction of the incised edges, it was some time before I discovered that the apparent monstrosity had been artificially produced. Lastly, I may add that many of the older writers were well acquainted with larval and other anomalies. Thus Rudolphi described a two-headed Cysticercus from a Lemur, and also a double-headed *Tænia crassicollis*. This worm had a tripartite body; as had likewise a *Tænia crassicollis* of which he did not possess the head (*corpore prismatico*). Other monstrosities were described and figured by Bremser and Creplin. Pallas mentions a two-headed Tricuspidaria (*Triænophori nodulosi bicipites*), and, as already stated at p. 97, a double-headed Cysticercus has been obtained from the liver of a sheep.

Before quitting the *Tæniæ* proper, I may observe that several other species have been indicated, based on ovular and other insufficient characters. To these belong Ransom's supposed tapeworm, and also Weinland's *Tænia megalöon*.

Bibliography (No. 18).—*Bonnet, C.*, 'Œuv. Compl.,' tom vi, p. 191, 1791.—*Bremser*, Atlas, by Leblond, Pl. iv.—*Chaussat*, 'Comptes Rendus,' p. 20, 1850.—*Cobbold*, 'Catalogue of the specimens of Entozoa in the Museum of the Royal College of Surgeons of England,' Nos. 118—121, London, 1866.—*Idem*, 'Worms,' l. c., p. 78.—*Idem*, "On a Cysticercus from the Human Brain," 'Brit. Assoc. Rep.,' 1870.—*Creplin*, 'Tænia

Monstrum, &c.,' Berlin, 1839.—*Cullingworth, C. J.*, "Notes on a remarkable specimen of Tapeworm (*Tænia lophosoma*, Cobbold)," 'Med. Times and Gaz.,' Dec., 1873.—*Davaine*, 'Les Cestoïdes,' l. c., p. 570. — *Diesing*, 'Zwanzig Arten von Cephalocotyleen,' figs. 1 and 2, taf. ii (aus dem xii, Bd. d. denkschr. d. Math.-nat. Cl. d. k. Akad.), Wien, 1856.—*Dujardin*, l. c., p. 619.—*Heller*, l. c., s. 600.—*Küchenmeister*, l. c., Eng. edit., p. 139.—*Leuckart*, l. c., s. 303 and 465.—*Levacher*, 'Journ. l'Institut,' p. 329, 1841.—*Pittard, S. R.*, Remarks in his article "Symmetry," Todd's 'Cyclop.,' vol. iv, p. 848, 1849-52, in which he refers to a monstrous Bothriocephalus (*T. lata*) in the Hunterian Museum, old 'Catalogue of Nat. Hist.,' pl. iv, p. 50, No. 205; see also my 'Catalogue,' l. c., *supra*, No. 167.—*Ransom*, in Reynolds' 'System of Medicine.' — *Rudolphi*, 'Synops.,' p. 545 and 598-9, with fig. showing the heads of *Cystic. Simiæ* (biceps), widely apart, 1819.—*Weinland* (*T. megalöon*), in Zoolog. Garten, Frankf., 1861, s. 118.—*Idem*, 'Essay,' l. c., p. 11.

Bothriocephalus latus, Bremser.—This species, though seldom seen in England, is sometimes brought hither by persons who have been residing for a time in foreign countries. It is indigenous in Ireland, and, though by no means common there, has been called the Irish Tapeworm. As regards its distribution in Europe it is much more prevalent in some districts than in others. On this point Leuckart remarks that "foremost amongst these are the cantons of West Switzerland, with the adjacent French districts. In Geneva, according to Odier, almost a fourth part of all the inhabitants suffer from Bothriocephalus. It is also common in the north-western and northern provinces of Russia, in Sweden, and in Poland. In Holland and Belgium it is likewise found, but, on the whole, not so frequently as in the first-named countries. Our German fatherland also harbours them in some districts, especially in eastern Prussia and Pomerania, and there have appeared cases in other places, as in Rhenish Hesse, Hamburg, and even in Berlin; these being apparently spontaneous instances."

Unlike the ordinary tapeworms, the segments of the broad tapeworm do not individually separate so as to become independent organisms, a circumstance which is highly favorable to the bearer. Its remarkable breadth, and the extremely numerous and closely-packed proglottides, impart a sufficiently distinctive character; but this parasite may be more fully characterised as

the largest human cestode at present known, attaining a length of more than twenty-five feet, and sometimes measuring nearly an inch in breadth; the so-called head $\frac{1}{25}''$ in width, bluntly pointed at the tip, much elongated or club-shaped, slightly flattened from behind forwards, and furnished with two laterally disposed slit-like fossæ or grooves, but destitute of any armature: anterior or sexually-immature segments of the body extremely narrow, enlarging in a very gradual manner from above downwards; joints of the lower half of the body gradually decreasing in width, but enlarging in depth; sexually-mature segments usually about $\frac{1}{8}$ of an inch in depth, but those near the caudal extremity frequently $\frac{1}{4}''$, and quadrate in form; body flattened, but not so uniformly as obtains in the ordinary tapeworms, being rather thicker near the central line; total number of joints estimated at nearly 4000, the first sexually-mature ones being somewhere about the six hundredth from the head; reproductive orifices at the central line, towards the upper part of the segment at the ventral aspect, the vaginal aperture being immediately below the male outlet, and both openings surrounded by papillæform eminences; uterus consisting of a single tube, often seen regularly folded upon itself, forming an opaque, conspicuous, centrally-situated rosette; eggs oval, measuring $\frac{1}{350}''$ in length by $\frac{1}{550}''$ in breadth, having three shell-coverings, and a lid-like operculum at one end, as occurs in the fluke-worms. Owing to the dark color of the egg shells, the uterine rosette is readily seen by the naked eye as a conspicuous deep brown spot at the centre of each successive segment.

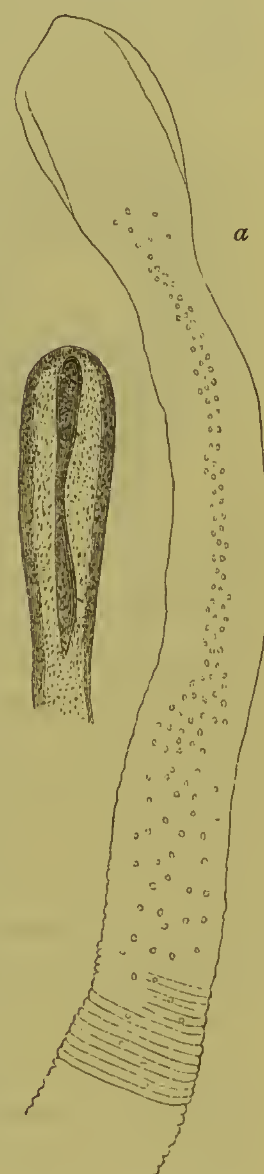

FIG. 25.—Head and neck of *Bothriocephalus latus*. *a*, Front view. The smaller figure represents the head as seen from the side. After Knoch.

The source and development of this parasite are points of considerable interest. The eggs are of comparatively large size, and after expulsion and immersion in water they give passage to beautifully ciliated embryos, which latter produce larvæ furnished with a boring apparatus. These larvæ resemble the six-hooked embryos of other tapeworms. In what animals the

larvæ subsequently develop themselves is not ascertained with certainty, but it is probable that persons become infested by eating imperfectly cooked fresh-water fish. Leuckart has suggested that the intermediary bearers are species of the salmon and trout family. Dr Knoch, of Petersburg, thought that there was no need of the intermediate host. He believed that he had succeeded in rearing young broad tapeworms in the intestines of dogs. It was Leuckart who first explained the source of Knoch's errors of interpretation. Although Knoch administered eggs of *Bothriocephalus latus* to dogs, and afterwards found young tapeworms of the species in question in the intestines of the dogs, it did not logically follow that any genetic relation (as between the egg-contents and the adult worms) had been thereby established. The circumstance that ripe ova of the Bothriocephalus always contain six-hooked embryos, must alone imply that an intermediate host is necessary for the formation of Cysticerci or measles. If the broad tapeworm could be reared in a direct manner by the administration of Bothriocephalus eggs, there would be no need for the presence of boring hooklets in the proscolex. These are necessary for invading the flesh of some intermediate host.

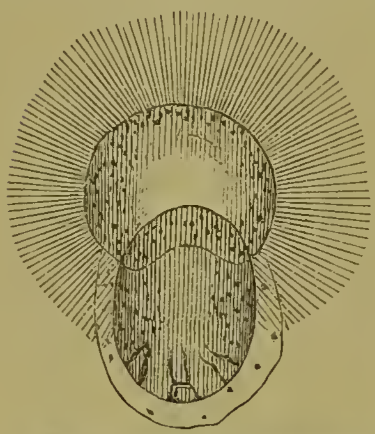

FIG. 26.—Proscolex, or six-hooked embryo of *Bothriocephalus*, escaping from its ciliated covering. After Leuckart.

Dr Fock, of Utrecht, has sent me particulars of an interesting case, and he suggests that infection comes from the little river bleak (*Leuciscus alburnus*). Writing from Utrecht in December, 1877, Dr Fock, after referring to a former case, goes on to say :—

"Permettez moi, cher confrère, que je rappelle à votre souvenir que vous avez eu l'obligeance de communiquer au public une observation, de ma main, sur un cas très rare de ver rubanaire, d'un Bothriocephale, chez une petite fille juive. Malheureusement je n'ai pu en donner de plus amples détails, parce que cette enfant n'a plus, depuis ce temps-là, rendu la plus petite parcelle de ver. Il y a maintenant quinze mois, et voilà que de nouveau un cas pareil se présente. Une femme mariée, frisonne, et, cette fois-ci encore, juive, s'est adressée à moi pour la débarasser de son ver. Elle me disait avoir rendu, il y a quelque temps, des fragments, ou plutôt un fragment de la

longueur d'un mêtre, d'un ver solitaire, pour lequel elle avait été traitée, sans succès, par son médecin ordinaire. A cause de cela elle s'adressa à moi, et je lui ai repondu qu'elle devrait revenir la première fois qu'elle rendrait de nouveau, spontanément, un nouveau fragment. Après un mois d'intervalle elle est revenue en me montrant un fragment de la longueur d'un demi-mêtre qu'elle venait de rendre spontanément, après avoir jeûni par précepte réligieuse, et deux jours après cela, traitée par l'écorce de grenadier, elle a rendu un Bothriocephale parfaitement conditionné en entier.

" Ce cas me semble assez intéressant pour être communiqué de nouveau, d'abord parce que jusqu'ici personne n'a pu dire par quel chemin a pu s'introduire un tel helminthe, et ensuite parce que ce chemin doit se présenter bien rarement dans nos contrées (ou en Angleterre) puisque dans le courant d'une trentaine d'années ayant rencontré des centaines de tænias, ce cas-ci est seulement le second dont je suis gratifié. Il me semble digne de réflexion que ce cas-ci se présente cette fois-ci de nouveau chez une juive. Est ce cas-ci fortuit, ou bien y-a-t'il un lien de causalité entre ce ver rare et le genre de nourriture ou de boisson de ces bonnes gens ? La dame me recontait que, en Frise, il y a un poisson très recherché qui s'appelle en Hollandais blèck, en Anglais blay ou bleak, et dont ils sont très friands, dans lequel, ils rencontrent très souvent un tres grand ver rubanaire. Une autre personne me disait avoir été à table chez un ami, qui ne sachant probablement ce qu'il mangeait, savoura avec beaucoup de délice cette friandise dégoutante."

After describing the specimen, Dr Fock concludes his remarks with a suggestion as to the possibility of introducing tapeworm into the human body by potable water, into which Cysticerci have accidentally found their way. Dr Fock remarks :—" J'ajoute une réflexion par rapport à la provenance des autres tænias, qui jusqu'ici sont introduits par l'usage de la viande non assez cuite ou rôtie, ou saignante ; mais, ne se pourrait-il pas que des débris de la chair d'un animal ladre fussent introduits fortuitement dans l'eau, par example, d'un fossé, et que celle-ci employée comme boisson contint des Cysticerques et par ainsi aussi une cause de Tænia ? Ce n'est qu'une conjecture que je propose en terminant cet article."

Although I cannot at all agree with Dr Fock in regarding water as a source of infection in the manner he indicates, yet

the still more recently expressed opinions of MM. Bertolus and Duchamp, based on experimental researches, render it tolerably certain that Leuckart's original surmise was correct, and that we must look to freshwater fishes for the larvæ of the broad tapeworm. In the section of this work devoted to the parasites of fishes I shall make particular allusion to the experiences of Dr Bertolus; but as confirming the view of Leuckart I may here observe, that Bertolus has almost proved that the so-called *Ligula nodosa* infesting the common trout is merely a sexually incomplete example of *Bothriocephalus latus*. The bleak (*Leuciscus alburnus*) shares with other freshwater fishes the privilege of harbouring a species of *Ligula* (*L. digramma*); but whether this form bears any genetic relation to our human *Bothriocephalus latus* can only be determined by actual experiment. If, as Duchamp and others have either indicated or implied, *Ligula alburni* is a synonym of the bleak's cestode in question, then it is evident that the sexually mature form of the *Ligula* of the bleak is the well-known *L. simplicissima* of many water birds and of a few other avian species. Probably the bleak-eaters of Holland consume many kinds of freshwater fishes, including various species of the salmon and trout family.

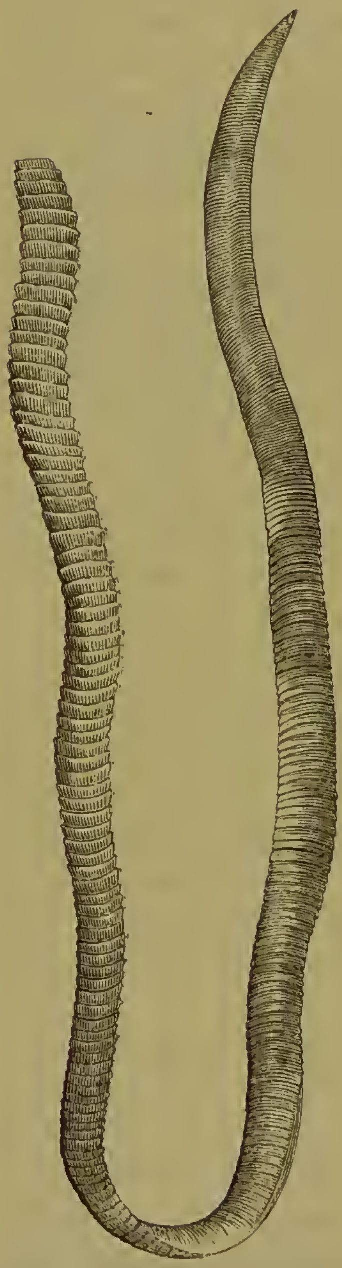

FIG 27.—Strobile of *Bothriocephalus cordatus*. After Leuckart.

The symptoms occasioned by *Bothriocephalus latus* do not differ materially from those produced by other tapeworms. According to Odier, as quoted by Davaine, there is not unfrequently a tumid condition of the abdomen, with sickness, giddiness, and various hysterical phenomena occurring at night. Pain in the region of the heart, palpitations, and faintness are also mentioned.

As already hinted, this cestode is very liable to present

abnormalities of structure, the proglottides frequently displaying double sexual orifices, with corresponding duplication of the reproductive organs internally. For details respecting the anatomy of *Bothriocephalus* I must refer to the works of Küchenmeister and Leuckart; and more particularly to the memoir of Drs F. Sömmer and L. Landois, who have supplemented the previous researches of von Siebold, Leuckart, Böttcher, Stieda and others by beautiful investigations of their own. In the pages of 'Nature,' for 1872, I gave a *résumé* of Sömmer's memoir, which will be found quoted below.

Bothriocephalus cordatus, Leuckart.—This species is identical with a worm long ago described by Pallas and Linneus. At present it is only known to infest the residents of North Greenland, but it is probably distributed throughout the north generally. It attains the length of about one foot, and has a small heart-shaped head, whose apex is directed forwards. The neck is so obscure that it may be said to be altogether wanting, the segmentation of the body being well marked immediately below the head. Though so small a species, Leuckart, who first described it, counted between six and seven hundred joints. As in the broad tapeworm, the reproductive orifices are serially disposed along the centre of the ventral line, but a close inspection shows that the folds of the egg-bearing organ are comparatively more numerous. This worm does not appear to be a frequent resident in the human body, though it is by no means uncommon in the dog. Possibly it may yet be found in the inhabitants of some of our northern and western isles.

Fig. 28.—Head of *Bothriocephalus cristatus*, viewed from the front. After Davaine.

Bothriocephalus cristatus, Davaine.—This cestode measures between nine and ten feet in length, and is characterised by the presence of two remarkable prominences, together forming a sort of rostellum or crest which is covered by numerous minute papillæ. The full-grown segments are less than half an inch in breadth; the body of the parasite being narrower than that of the broad species. The original description of the parasite by Davaine

is based on two specimens, one of which, quite perfect, was obtained from a child five years old, under Dr Féréol's care at Paris. The other was passed spontaneously by an adult residing at Haute-Saône. I have here copied one of Davaine's original figures of the head of the worm.

BIBLIOGRAPHY (No. 19).—*Bertolus*, "Mém. sur le development du *Dibothrium latum*" (in Appendix to Duchamp's work, see Bibliog. No. 59).—*Blanchard*, "Recherches, &c.," 'Ann. des Sci. Nat.,' ser. 3, Zool., Pl. 11, 12, 1848.—*Böttcher*, "Studien ueber den Bau des *Both. latus*," 'Virchow's Archiv,' s. 97 *et seq*, 1864.—*Bremser*, l. c., Bibl. No. 1, s. 88, 1824.—*Chiaje*, 'Compendio, &c.,' Tab. iii, figs. 1—5, 1833.—*Cobbold*, 'Entoz.,' p. 289, 1864. *Idem*, "Remarks on the Broad Tapeworm" (with a letter from Dr Fock), the 'Veterinarian,' July, 1878.—*Creplin*, in Ersch and Gruber's 'Encyclop.,' 1839, p. 296.—*Davaine*, 'Traité,' l. c., 1860; 2nd edit. (*passim*), 1877.—*Idem*, art. 'Les Cestoïdes,' l. c., Bibl. No. 2, p. 580—591, 1876.—*Dujardin*, l. c., Bibl. No. 1, p. 612, 1845.—*Eschricht, D. F.*, 'Anat-physiol. Untersuchungen ueber die Bothriocephalen,' Breslau, 1840. —*Fock* (see Cobbold).—*Heller*, 'Darmschmarotzer,' l. c., s. 606, 1876.—*Knoch*, 'Petersburger Med. Zeitschrift,' 1861.—*Idem*, 'Die Naturgeschichte des breiten Bandwurms (*B. latus*, auct.),' St Petersburg, 1862.—*Küchenmeister*, 'Ueber cestoden,' l. c., 1853.—*Leuckart*, 'Die Blasen Bandwürmer,' 1856.—*Idem*, 'Die mensch. Par.,' Bd. i, s. 414—448, und 757, 1863; and Bd. ii, s. 866, 1876.—*Owen*, Todd's 'Cyclop.,' 1837.—*Sömmer* und *Landois*, aus Sieb. und Köll. Zeitschr., 'Beiträge zur Anatomie der Plattwürmer,' Leipsig, 1872; see also the *résumé* in 'Nature' for Aug., 1872, p. 278.—*Wawruch*, 'Pract. Monograph. d. Bandwürm-Krankheit,' 1844, s. 33.

Echinococcus hominis (the common hydatid).—This larval entozoon has acquired various names according to the kind of bearer in which it happens to have been found; but all the true hydatids or acephalocysts, whether infesting man or animals, are referable to one and the same species of parasite. They have been termed *Echinococcus hominis*, *E. veterinorum*, *E. polymorphus*, *E. exogena*, *E. endogena*, *E. multilocularis*, according to circumstances. All of them represent a juvenile stage of the *Tænia echinococcus* or hydatid-forming tapeworm which infests the dog and wolf. Experimental proof of this fact has been furnished by Von Siebold (1852), Haubner, Leuckart, Küchenmeister, Van Beneden, Naunyn, Nettleship, Krabbe, and others.

The first successful rearing of *Tæniæ* with human hydatids was accomplished by Naunyn (1864), his results being subsequently verified by Krabbe and Finsen (1865). Zenker, Ercolani, and several others, including myself, also conducted feeding experiments with human hydatids which were attended with negative results. In the case of one of my experimental dogs the animal was liberated by an ill-disposed person before I had opportunity to destroy it. As the experiment was carefully conducted, the animal may have proved a source of fresh echinococcus-infection. Mr E. Nettleship's eminently successful experiment was made with hydatids obtained from a sheep. The converse experiment, namely, that of rearing hydatids with the mature proglottides of *Tænia echinococcus* administered to animals, has been performed most successfully by Leuckart, and by Krabbe and Finsen; by the former in the pig, by the latter in a lamb, with tapeworms that had also been reared by experiment. Zenker, later on, reared the *Tænia* from hydatids obtained from an ox.

The sexually mature *Tænia echinococcus* may, for the purposes of diagnosis, be characterised as a remarkably small cestode, seldom reaching the fourth of an inch in length and developing only four segments, including that of the head; cephalic extremity capped by a pointed rostellum, armed with a double crown of comparatively large-rooted hooks, from thirty to forty in number; the four suckers prominent, and succeeded by an elongation of the segment forming the so-called neck; final segment, when sexually mature, equalling in length the three anterior ones; reproductive papilla at the

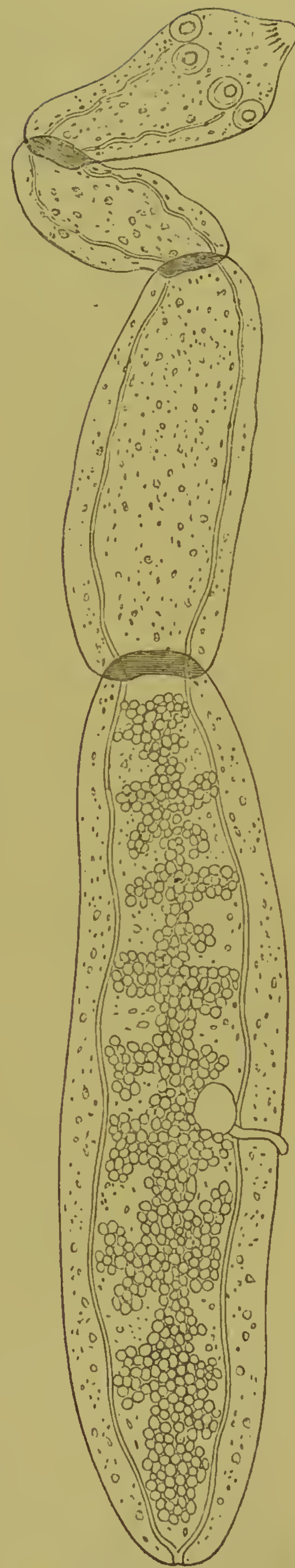

FIG. 29.—*Tænia echinococcus* Strobile. Mag. 30 diam. Original.

margin of the proglottis rather below the central line; proscolex or embryo giving rise to the formation of large proliferous vesicles, within which the scolices or echinococcus-heads are developed by gemmation.

When an animal is fed with the mature proglottides of *Tænia echinococcus* the earliest changes that take place are the same as obtain in other cestodes. The segments are digested; the shells of the ova are dissolved; the six-hooked embryos escape. The embryos bore their way into the organs of circulation, and thence they transfer themselves to the different organs of the host; being especially liable to take up their abode in the lungs and liver. Having arrived at this, their resting stage, the embryos are next metamorphosed into hydatids. According to Leuckart's investigations the juvenile hydatid is spherical at the earliest stages; being surrounded by a capsule of connective tissue formed from the organs of the host. After removal from its capsular covering, the vesicle consists of a thick laminated membrane, forming the so-called cuticular layer, and a central granular mass, which subsequently becomes enveloped by a delicate granular membrane. At the fourth week the echinococcus capsule measures about $\frac{1}{25}''$ in diameter, its contained hydatid being little more than half this size. Its future growth is by no means rapid, seeing that at the eighth week the hydatid has attained only the $\frac{1}{15}''$ in diameter. At this period the central granular mass develops a number of nucleated cells on the inner surface of the so-called cuticle. These cells, which at first are rounded or oval, become angular or elongated in various directions, and even distinctly stellate; and in this way a new membrane is formed, constituting the so-called inner membrane or granular layer. The intermediate stages between this condition and that of the fully-formed echinococcus hydatid have not been satisfactorily traced in detail; nevertheless, Krabbe and Finsen's experiment on a lamb showed that within a period of little more than three months well-developed echinococcus-heads may be formed in the interior of the vesicles. It is thus clear that the production of scolices immediately follows the formation of the granular layer, and this is succeeded, though not invariably, by the formation of daughter- and grand-daughter-vesicles, which are sometimes termed "nurses." These latter may be developed exogenously or endogenously.

The appearance of hydatids varies very much according to

their mode of formation, to the kind of host in which they are present, and to the character of the organs in which they happen to take up their residence. The so-called exogenous type occurs sparingly in man, whilst the endogenous type is very abundant. The peculiar form known as the multilocular echinococcus is probably a mere variety of the exogenous type. The exogenous and endogenous hydatids may coexist in the same bearer. In the lower animals we commonly find the organs of the body occupied by numerous lobulated cysts, varying in size from a walnut to a goose's egg, but sometimes rather larger. They are rarely solitary, being particularly liable to occupy both the liver and lungs in the same animal. The viscera are sometimes crowded with cysts. The hydatids do not usually protrude much beyond the surface of the infested organ, but lie imbedded within its parenchymatous substance.

The multilocular variety was first described by Virchow. In reference to it Leuckart writes as follows:

"Hitherto we know this growth only from the liver, in which it forms a firm, solid, and tolerably rounded mass of the size of the fist or even of a child's head. At first sight it looks more like a pseudoplasm than a living animal parasite. If you cut through the tumour, you recognise in its interior numerous small caverns, mostly of irregular shape, and separated from one another by bundles of connective tissue, more or less thick, and including a tolerably transparent jelly-like substance. In the intervening stroma a blood-vessel or a collapsed bile-duct runs here and there; but there is nowhere any trace of true liver substance. The outer boundaries of the tumour are in most cases pretty well defined, so that the attempt to cut these growths out is not difficult. In particular spots, especially at the surface, one sometimes sees white, moniliform, jointed lines passing off from the tumour, and even thicker terminations which, perhaps, expand in the neighbouring liver-parenchyme into new (multilocular) groups of different size. In one case, recorded by Virchow, the growth extended, together with Glisson's capsule, a long way towards the intestine." To this description it may be added, that the growth on section presents an appearance not altogether unlike alveolar colloid, having, in point of fact, been confounded with that pathological product, with which, however, as stated by Virchow, it has nothing in common. This is proved not only by the occurrence of the pathological features above mentioned, but also, more

particularly, by the well-ascertained presence of echinococcus-heads in most of the so-called alveoli. Several hypotheses have been broached with the view of explaining the mode in which these multilocular hydatid growths are formed. Virchow thought that the echinococcus vesicles were primarily formed in the lymphatic vessels, whilst Schröder van der Kolk supposed that they originally took up their abode in the biliary ducts. Although, thanks to the courtesy of Professor Arnold Heller in giving me a specimen, I have been enabled to confirm much that has been written in respect of the morbid appearances, I can add nothing towards the solution of the difficulty in question. Until lately it was supposed that the multilocular variety of hydatids only existed in man, but Professor Böllinger has encountered it in the liver of a calf.

Selecting any ordinary fresh example of the exogenous kind, and laying the tumour open with a scalpel, we notice in the first instance an escape of a clear transparent, amber-coloured fluid. This previously caused the distension of the sac. If the tumour is large, this escape will probably be followed by a falling in, as it were, of the gelatiniform hydatid membrane, in which case the inner wall of the external adventitious investment or true fibrous cyst will be laid bare. If the hydatid be next withdrawn from the cyst, it will be seen to display a peculiar tremulous motion, at the same time coiling upon itself wherever there is a free-cut margin. Further examination of portions of the hydatid will show that we have two distinct

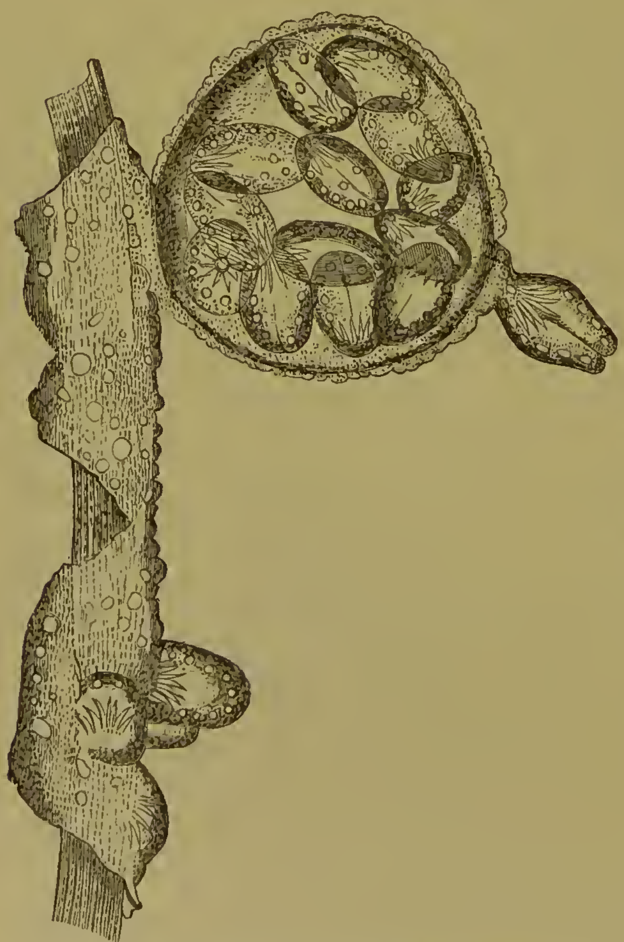

FIG. 30.—Ectocyst, endocyst, and brood capsule of *Echinococcus*. From a Zebra. After Huxley.

membranes; an outer, thick, laminated, homogeneous elastic layer (the *ectocyst* of Huxley), and an internal, thin, soft, granulated, comparatively inelastic layer—the *endocyst* of the same author. The terms are convenient. The ectocyst is structureless, consisting of a substance closely allied to chitine. For this and other reasons it has been called the cuticular layer, but the endocyst is the essential vital part of the animal, representing a huge compound caudal vesicle. In an hydatid from the zebra, Huxley found that the endocyst was "not more than $\frac{1}{2000}$th of an inch in thickness, being composed of very delicate cells of $\frac{1}{2000}''$ to $\frac{1}{5000}''$ in diameter, without obvious nuclei; but often containing clear, strongly refracting corpuscles, generally a single one only in a cell." Prof. Huxley adds: "These corpuscles appear to be solid, but by the action of dilute acetic acid the interior generally clears up very rapidly, and a hollow vesicle is left of the same size as the original corpuscle. No gas is developed during this process, and sometimes the corpuscles are not acted upon at all by the acid, appearing then to be of a fatty nature. A strong solution of caustic ammonia produces a concentrically laminated or fissured appearance in them. Under pressure and with commencing putrefaction a number of them sometimes flow together into an irregular or rounded mass."

The precise mode of development of the echinococcus-heads or scolices has been a subject of lengthened discussion between Leuckart and Naunyn. According to Leuckart the earliest indication of the scolex consists of a slight papillary eminence on the inner surface of the granular endocyst. After a short period this prominence displays in its interior a vacuole-like cavity, the latter being occupied, however, with a clear limpid fluid. Its margins become more and more clearly defined, until the cavity is by and by seen to be lined with a distinct cuticular membrane. The papilla increasing in size, becomes at first elongated or oval, eventually scoleciform, or even, perhaps, a true echinococcus-head. Thus far the description bears out, in a measure, the theoretical notions entertained by the older authors; but the developmental process does not stop here. The scolex-development has now to sacrifice itself by developing in its interior a brood of scolices or echinococcus-heads. In other words, it becomes transformed into the so-called brood-capsules of Leuckart and other authors. These structures were previously well known to Professors Erasmus Wilson and George

Busk. Mr Wilson spoke of the capsule as "*a delicately thin proper membrane*, by which the Echinococci are connected with the internal membrane of the acephalocyst" ('Med.-Chir. Trans.,' 1845, vol. xxviii, p. 21). Mr Busk described the echinococcus-heads as "attached to a common central mass by

Fig. 31.—Group of Echinococcus-heads, from an hydatid found in the liver of a sheep. Magnified about 25 diameters. From a drawing by Professor Busk.

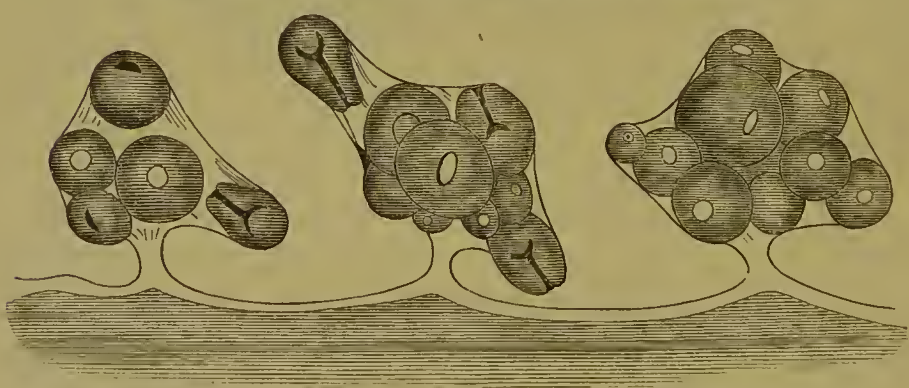

Fig. 32.—Three brood-capsules, containing Echinococcus-heads. Magnified 76 diameters. After Professor Erasmus Wilson.

short pedicles, which appear to be composed of a substance more coarsely granular, by far, than that of which the laminæ of the cyst are formed. This granular matter is prolonged beyond the mass of Echinococci into a short pedicle common to the whole, and by which the granulation is attached to the

interior of the hydatid cyst." What Mr Busk here describes as a granulation can only be equivalent to the brood-capsule and its entire contents, but he elsewhere speaks of the capsule itself as a "delicate membranous envelope." It should be borne in mind that Busk's paper was communicated to the Microscopical Society so early as the 13th Nov., 1844; being published in the 'Transactions' for that year.

In the completely developed state the echinococcus-heads exhibit somewhat variable characters as to size and form, the latter differences being, for the most part, dependent upon their degree of contraction and vitality. In the perfect condition they vary from the $\frac{1}{60}''$ to the $\frac{1}{100}''$ in diameter, being usually about the $\frac{1}{80}''$. They are solid, and when stretched out exhibit an hour-glass-like constriction at the centre of the body, which divides the scolex into an anterior part supporting the rostellum and suckers, and a posterior part which has been compared to the caudal vesicle of ordinary Cysticerci. The rostellum supports a double crown of hooks, but the disparity of the two series is scarcely sufficiently marked to render their distinction obvious. The hooks of the smaller row vary in size from $\frac{1}{1040}''$ to $\frac{1}{830}''$ of an inch, whilst those of the larger series are from $\frac{1}{830}''$ to $\frac{1}{555}''$. In all instances the root-processes are incompletely developed, and consequently vary in thickness. They are, as Leuckart also has stated, apt to exhibit abnormalities.

FIG 33.—Separate *scolex*, or echinococcus-head. Magnified 500 diameters. After Huxley.

In regard to the development of the echinococcus-heads it further remains for me to observe that a distinct water-vascular system is recognisable in the scolices. By the intervention of the pedicle of the scolex this system is connected with the brood-capsule, and also with the vessels of

the maternal endocyst. In the scolex there exists a circular channel immediately below the rostellum, and this ring, on either side, gives off two vessels which pass downwards in a tortuous manner, internally, until they arrive at the pedicle where they unite to form two channels, which latter are continued into the vascular system of the maternal endocyst. In the retracted condition their position, of course, becomes very much altered, and they form loops on either side of the central line which marks the space leading down to the inverted head. Neither Prof. Huxley nor myself have seen these vessels, which Leuckart observed in the scolex itself, but Huxley discerned some apparently loose cilia in the granular parenchyma of the body; their longitudinal measurement being about the $\frac{1}{3500}$ of an inch.

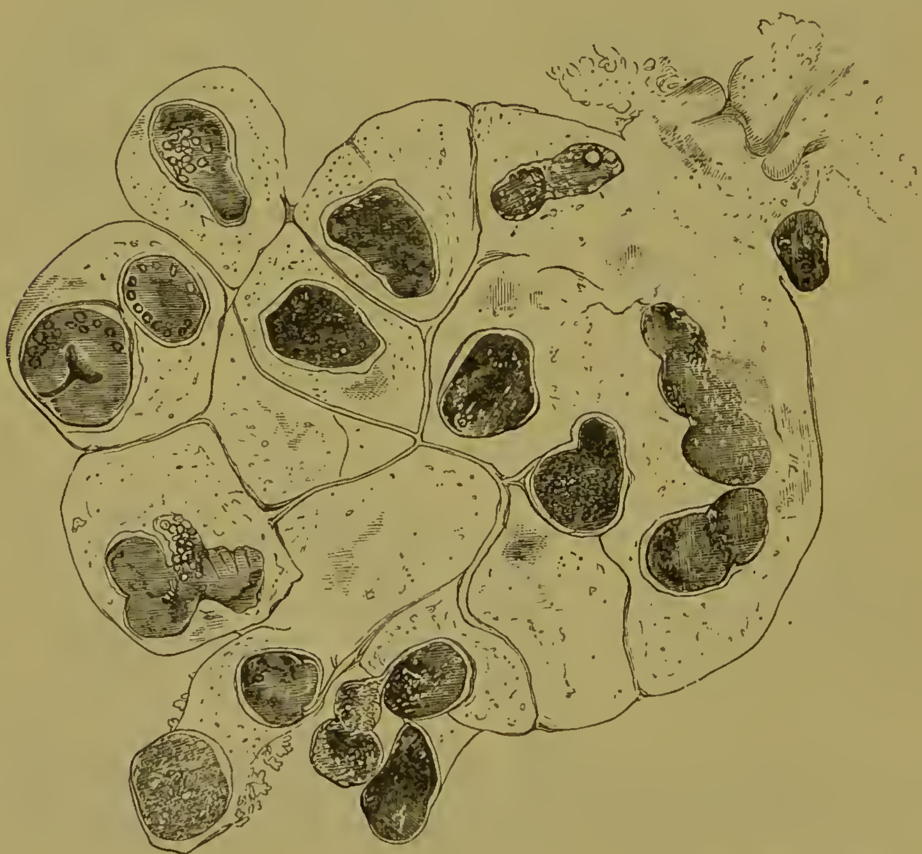

FIG. 34.—An Echinococcus brood-capsule (flattened by pressure). Magnified about 120 diameters. From a drawing by Professor Busk.

As regards the production of "nurses" by the phenomenon of proliferation, I can only remark that the endocyst is primarily concerned. The secondary and tertiary vesicles must be regarded as so many special bud-developments which, instead of becoming brood-capsules, become daughter-vesicles and

grand-daughter vesicles, constantly developing in their interior secondary and tertiary brood-capsules and scolices, but sometimes, it would appear, developing neither the one nor the other. This is the view of Naunyn, which is somewhat opposed by Leuckart, who holds that the vesicles ordinarily arise from within the layers of the ectocyst. Speaking of these daughter-hydatids Leuckart remarks that "Naunyn denies that they take their origin between the lamellæ of the mother bladder—a fact, however, which, in agreement with Kuhl and Davaine, I have seen more than once and have followed out step by step." For my own part I incline to the belief that the process as observed by Leuckart is exceptional, and that under ordinary circumstances it occurs as Naunyn has described it. Thus the long and short of the whole matter appears to be that the endocyst is capable of forming solitary scolices. Some of the scolices become differentiated to form brood-capsules, a portion of whose individual echinococcus-heads may, in their turn, become secondary brood-capsules, whilst others fail to become either scolices or brood-capsules. It accords with our knowledge of the general plan of development to believe that the daughter and grand-daughter hydatids are likewise peculiarly modified scolices. They are, in short, buds of the endocyst.

The distribution of hydatids throughout the organs of the bearer, and their prevalence in particular countries, has especially engaged my attention. I have personally examined upwards of a thousand preparations of entozoa in our public collections; and of these, 788 are preserved in the anatomical and pathological museums of the metropolis. By this inspection I have obtained a tolerably accurate knowledge of the pathology, localisation and effects produced by the presence of bladder-worms in at least 200 unpublished cases of hydatid disease. Most of our museums exhibit one or more specimens that are unique. After making certain necessary deductions, I find that I have 192 new cases to add to the 135 cases of hydatid disease that I had previously recorded, affording a total of 327 cases available for statistical purposes. If an analysis of these cases be made and compared with the statistics furnished by Davaine, and if the whole be reduced to the lowest number of practically available terms, we at length obtain a result which, although it may be only approximatively correct, is nevertheless of much practical value and significance. The statistics in question stand as follows:

Organs affected.	Davaine.	Cobbold.	Total.
Liver	165	161	326
Abdomen, including spleen	26	45	71
Lungs	40	22	62
Kidney and bladder	30	23	53
Brain	20	22	42
Bones	17	16	33
Heart and pulmonary vessels	12	13	25
Miscellaneous	63	25	88
Total	373	327	700

In the main Davaine's table and my own show a remarkable correspondency, as is seen in the numbers referring to hydatids of the liver, heart, and bones respectively. Where our results do not correspond the explanation of the discrepancy is sufficiently simple. The abdominal cases here credited as such in Davaine's table are placed by him under *pelvis*, whilst the abdominal cases in my own table not only include the pelvic hydatids, but also two *spleen* cases, and nineteen others from the peritoneum and intestines.

As the facts here stand, the liver cases comprise nearly $46\frac{1}{2}$ per cent. In a large number of cases the entozoon has taken up its abode in organs of vital importance. If statisticians and officers of health would obtain an adequate conception of the fatal capabilities of parasites, they should consider these data. In 6 per cent. of all these cases the bladder worm has found its way into the brain, and of course proved fatal to the bearers; in about $3\frac{1}{2}$ per cent. more they took up their residence in the heart, also proving fatal; whilst of all the other cases put together I reckon that not less than 15 per cent. were concerned in bringing about the death of their hosts. I probably underrate the fatal capabilities of echinococcus disease when I express the conviction that hydatids prove fatal to 25 per cent. of all their human victims.

The recently published analysis of 983 cases by Dr Albert Neisser affords similar results. Of these, 451 were referable to the liver, or 45·765 per cent. The other cases, reduced as above, show in the main a similar correspondency.

It may be asked if these facts afford us any assistance in determining the amount of injury that we, as a people, sustain either directly or indirectly from hydatids. On carefully reviewing all the data before me, I may say that it is difficult

to draw very precise conclusions; albeit it is not mere guess-work when I assert that in the United Kingdom several hundred human deaths occur annually from this cause. In some other countries the proportion is far greater; the oft-quoted case of Iceland, where the disorder is fatally endemic, still standing at the head of the afflicted territories.

Our Australian colonies are probably entitled to the next place of distinction in this respect. We have strong and recent evidence of the truth of this statement. Thus a writer in the 'Australian Med. and Surg. Review' says: "This disease is becoming unpleasantly frequent, and at present we have no reliable mode of treatment, either theoretical or empirical." Another writer observes ('Melbourne Argus,' May 18th, 1874), "Hydatid disease is endemic in this colony; and, though not so constantly met with as in Iceland, we may probably claim the doubtful honor of holding the second place in the list of countries so affected." In the 'Argus' for June 20th of the same year, another writer refers to the frequent notices of cases of hydatids published in the various local newspapers. A retired medical man, the late Mr J. P. Rowe, writing in the 'Melbourne Leader' (Sept. 7th, 1872), incidentally remarked on the "notable increase of hydatid disease in the human subject." Again, still more satisfactory evidence is afforded by a reviewer in the 'Leader' of the 31st January, 1874. Commenting on my manual, he not only takes occasion to speak of the prevalence of hydatids generally, but also supplies that kind of accurate statistical evidence of which we so much stand in need. He gives the following table, showing the number of *deaths* from hydatids in Victoria for eleven years. It is instructive in many ways.

Years.	Males.	Females.	Total.
1862	3	2	5
1863	3	2	5
1864	6	3	9
1865	9	6	15
1866	18	7	25
1867	13	12	25
1868	21	12	33
1869	12	10	22
1870	10	7	17
1871	6	9	15
1872	24	5	29
Total deaths in eleven years	125	75	200

To employ the writer's own words, "this mortality gives only a faint notion of the extreme prevalence of hydatids in Victoria, since numbers of cases are cured by tapping, and otherwise by medical treatment, or by spontaneous bursting of the cysts." Hydatids are often found post mortem where their presence has never been suspected during life. "To meet with hydatids as a cause of deranged health is now a matter of daily expectation with every medical practitioner." Lastly, Dr Dougan Bird, in his able brochure on 'Hydatids of the Lung,' fully confirms these statements, remarking that the rich and poor of the Australian metropolis suffer just as much from hydatids as do either the shepherds of the western plains, or the miners of Ballarat and Sandhurst.

Such are the facts from Australia. As regards home evidence, so far as I am aware, little or nothing has been done towards securing an accurate estimate of the mortality in England from echinococcus disease. The reports of the Registrar General give no sufficient sign. The explanation is not far to seek, since for the most part hydatids are either classed with diseases of the liver, or with those of the other organs in which they happen to have been present.

One of the most valuable contributions to our knowledge of the prevalence of hydatid disease affecting animals is that supplied by Dr Cleghorn, from a statistical table constructed by the executive commissariat officers stationed at Mooltan. The record in question shows that out of 2109 slaughtered animals, no fewer than 899 were affected with hydatid disease. This is equal to more than forty-two per cent. In the majority of cases, both the lungs and liver were affected, cysts were found 829 times in the liver and 726 times in the lungs. In a few instances they were present in the kidneys, and also occasionally in the spleen. The inference from all this is that in India, if not elsewhere, the echinococcus disease is much less common in man than it is in animals. The explanation is simple enough, since cattle have more ready access to, and less scruple in partaking of filthy water and food in or upon which the eggs of the *Tænia echinococcus* abound.

Into purely professional questions connected with the treatment of the echinococcus malady I do not here enter; nevertheless, in connection with hygiene I may observe that the prevalence of hydatids in any country is strictly dependent upon the habits of the people. The close intimacy subsisting

between the peasantry and their canine companions is the primary source of the endemic; and where dogs are not kept, it is well nigh impossible that the disease should be contracted. The fact that every Icelandic peasant possesses, on an average, six dogs, and that these dogs share the same dwelling (eating off the same plates and enjoying many other privileges of intimate relationship) sufficiently explains the frequency of hydatids in that country. According to Krabbe, the sexually mature *Tæniæ* occur in 28 p. c. of Icelandic dogs, whereas in Copenhagen he found it twice only in 500 dogs examined. In his work (quoted below, p. 58, or Fr. Edit., p. 60) Krabbe comments on a sensational passage which, in my introductory treatise (p. 283), I had quoted from a popular memoir by Leuckart ('Unsere Zeit,' s. 654, 1862). The practitioners whom we had spoken of as "quacks" are mostly homœopaths; and it appears that even those who are not in any legal sense professional men "treat their patients much in the same way as ordinary medical men." It simply comes to this, that, instead of *dog's excrement* forming with the aforesaid "quacks" a conspicuous or common remedy (as Leuckart's description had led me to infer), this nasty drug is now rarely administered, and by the grossly ignorant only.

Up to the present time no person has seen the *Tænia echinococcus* in any English dog which has not been previously made the subject of experiment, but considering the prevalence of hydatid disease amongst us, there can be no doubt that English dogs are quite as much if not more infested than continental ones. Probably, at least one per cent. of our dogs harbour the mature tapeworm. Certainly a great deal of good might accrue from the acquisition of more extended evidence respecting the prevalence of this and other forms of entozoa infesting man and animals in this country.

From Schleisner's table it appears that hydatids are more frequent in women than in men. Apparently, it is not so in Australia. As regards Iceland the explanation must be sought for in the different habits of life. No doubt, water used as drink by women is constantly obtained from supplies in the immediate neighbourhood of dwellings, and in localities to which dogs have continual access. The comparative rarity of the echinococcus disease amongst sailors is not so much dependent upon the circumstance that seamen's diet usually consists of salted provisions, as upon the fact that these men can seldom have

opportunities of procuring water from localities where dogs abound. In regard to water drinking, there is ground for believing that the addition of a very little alcohol is sufficient to destroy the six-hooked embryos of *Tænia echinococcus* whilst still *in ovo;* and there is no doubt that water raised to a temperature of 212° Fahr. will always ensure the destruction of the larvæ. Boiled water by itself is by no means palatable. The reason why the upper classes comparatively seldom suffer from hydatids may be attributed to the circumstance that those few who drink water take the very proper precaution to see that it is either "pump" or fresh spring water in which no living six-hooked embryos are likely to exist. So far as hydatids are concerned, wine and beer drinking is preferable to water-drinking; yet if water is carefully filtered no evil of the parasitic kind can possibly result from its imbibition. An ordinary charcoal filter will effectually prevent the passage of the ova, since their diameter is nearly $\frac{1}{370}$ of an inch.

From what has been stated it follows that personal and general cleanliness are eminently serviceable as preventions against infection, but to ensure perfect success other precautions must be exercised, especially in relation to our contact with and management of dogs. Leuckart puts this very clearly when he says:—"In order to escape the dangers of infection, the dog must be watched, not only within the house, but whilst he is outside of it. He must not be allowed to visit either slaughter-houses or knackeries, and care must be taken that neither the offals nor hydatids found in such places are accessible to him. In this matter the sanitary inspector has many important duties to perform. The carelessness with which these offals have hitherto been disposed of, or even purposely given to the dog, must no longer be permitted if the welfare of the digestive organs of mankind is to be considered. What blessed results may follow from these precautions may be readily gathered from the consideration of the fact that, at the present time, almost the sixth part of all the inhabitants annually dying in Iceland fall victims to the echinococcus epidemic" (l. c., s. 654). Similar measures had previously been recommended in less explicit terms by Küchenmeister, who in effect remarked that the principal thing was to ensure the destruction of the echinococcus vesicles. He also recommended the expulsion and annihilation of the *Tænia echinococcus*. In order to carry out this idea, it was suggested by Dr Leared

that every dog should be periodically physicked, and that all the excreta, tapeworms included, should be buried at a considerable depth in the soil. I advised, however, that in place of burying the excreta, *they should, in all cases, be burnt.* I had, indeed, long previously urged this measure (in a paper "on the *Sclerostoma* causing the gape-disease of fowls," published in 1861), with the view of lessening the prevalence of entozoa in general, whether of man or animals. The rule I suggested stood as follows :—*All entozoa which are not preserved for scientific investigation or experiment should be thoroughly destroyed by fire, when practicable, and under no circumstances whatever should they be thrown aside as harmless refuse.* As an additional security I recommended that boiling hot water be occasionally thrown over the floor of all kennels where dogs are kept. In this way not only would the escaped tapeworms be effectually destroyed, but also their eggs and egg-contents, including the six-hooked embryos. These measures were again advocated at the Cambridge Meeting of the British Association in 1862, and also more fully in a paper communicated to the Zoological Society, during the autumn of the same year ('Proceedings,' vol. xxx, pt. 3, pp. 288, 315).

As the scope and tendency of this work preclude the textual admission of clinical details, I must limit my remaining observations to the pathology of hydatid disease. At very great labor, pursued at distant intervals during a period of ten years, I sought to ascertain the probable extent and fatality of this form of parasitism in England, by going over such evidence as our pathological museums might supply. Although, from a statistical point of view, the investigation could hardly be expected to yield any very striking results; yet clinically viewed the study was most instructive. The evidence which I thus procured of numerous slow and painful deaths from echinococcus disease, further stimulated me to place a summary of the facts on record. Physicians, surgeons, scientific pathologists, and veterinary practitioners are alike interested in the study of hydatid disease; and I had not proceeded far in my careful investigation before it became evident to me that very great practical results would ensue if, in this kind of effort, the principle of division of labor had full play. At all events, within these museums lie concealed a mass of pathological data which, although well within reach, have not been utilised to the extent they ought to have been.

As a student of parasites for some thirty years, I must without offence be permitted to protest against the too frequent omission of parasites in statistical evidence as a cause of mortality. From facts within my own knowledge I can confidently assert that parasites in general, and hydatids in particular, play a far more important part in the production of disease and death than is commonly supposed. In saying thus much, however, I am not insensible to the fact that, in recent times, new methods of treatment combined with higher surgical skill, have greatly tended to lessen the fatality of this affection. In this connection I would especially refer to the recorded experiences of an able colonial surgeon, Dr MacGillivray, as made known in the pages of the 'Australian Medical Journal.' The able surgeon to the Bendigo Hospital, treated as in-patients, from 1862 to 1872, inclusive, no fewer than seventy-four cases of hydatid disease. He operated on fifty-eight of them. Two patients were tapped for temporary relief (as they were dying of other diseases); and of the remaining fifty-six only eleven died. No fewer than forty-five were discharged *cured*—a fact redounding largely, I should think, to the credit of Australian surgery.

In reference to museum evidence I have no hesitation in saying that the pathological collections in the metropolis abound in rare and remarkable illustrations of hydatid disease; most of the preparations being practically known only to such few members of the medical profession as have been at some time or other officially connected with the museums. Not without justice, curators often complain that their work and catalogues are turned to little account. As a former conservator of the Edinburgh University Anatomical Museum (1851-56), and subsequently as museum-curator at the Middlesex Hospital Medical College, I am in a position to sympathise with them. Valuable, however, as the catalogues are, it is often necessary to make a close inspection of the preparations in order to arrive at a correct interpretation of the facts presented.

Although the entozoal preparations in the museum attached to St Bartholomew's Hospital are, comparatively speaking, few in number, there are some choice specimens of hydatid disease. There is a remarkable case in which hydatids invaded the right half of the bones of the pelvis; death resulting from suppurative inflammation of the cysts. This patient, a woman, had also another hydatid cyst which was connected with the

ovary. Amongst the series contributed by Dr Farre, there is a case represented where a large cyst containing numerous hydatids "occupied the pelvis of an infant and produced retention of urine," which ultimately proved fatal. There are also several fine examples of hydatids from the omentum (Dr Farre's case), besides a good specimen of acephalocysts connected with the vesiculæ seminales. There are two other cases in which these larval entozoa were passed with the urine. At the time when I made my inspection, the entire series represented twenty-five separate cases, of which only one appears to have been published in detail (Mr Evans's case, 'Medico-Chirurgical Transactions,' 1832). In addition to the above, I must not omit to particularise two instructive preparations illustrative of a case in which an hydatid was lodged in the right half of the cerebrum. This was from a girl in whom head symptoms showed themselves a year before death, and in whom there was partial hemiplegia of the left side. I may add that there is also in the series a doubtfully genuine example of hydatids of the breast.

The collection in connection with the Westminster Hospital contains several highly interesting specimens of entozoa (one of which I believe to be altogether unique), but it is by no means rich in the matter of hydatids. Out of a score of preparations of parasites of various kinds, only four (apparently representing the same number of cases) are hydatids, all of which appear to have been connected with the liver. Two are certainly so, one of the latter (Mr Holthouse's case) showing calcareous degeneration.

The museum connected with St Mary's Hospital Medical School, in addition to several liver cases, contains one interesting example of hydatids of the lung (Dr Chambers's case), and also three valuable preparations illustrating Mr Coulson's remarkable case of hydatids affecting the tibia. One of the preparations shows the bone itself, which was eventually removed at the joint, the operation having been performed by Mr Spencer Wells.

Here, perhaps, it will not be out of place to mention as a fact of special clinical interest that I have encountered records of no fewer than nine other similar cases where hydatids have taken up their abode in the tibia, generally selecting the head or upper part of the bone. Some of my notes have been mislaid, but, speaking from recollection, one of the

choicest specimens which I have examined is that contained in the pathological museum of the Nottingham Hospital.

When I first went over the collection of the Middlesex Hospital Museum, I found it to contain fifty-four preparations of entozoa, of which some fourteen only were true hydatids, representing as many separate cases. There are now upwards of a score of preparations of hydatids, several of the cases having already had ample justice done to them by Dr Murchison in his well-known memoir ('Edinb. Med. Journ.,' Dec., 1865). Amongst the most interesting preparations I would especially call attention to two fine and genuine specimens from the kidney, another very large example of an hydatid situated between the bladder and rectum, a simple acephalocyst removed from the orbit (Mr Hulke's case), and the hydatid removed from the axilla by the late Mr Charles Moore. There is a jar containing hundreds of hydatids that were taken from the thoracic cavity of a dissecting-room subject, who was reported to have died of phthisis; and there is another preparation of an hydatid of the heart, which also proved fatal, without there having been the slightest suspicion entertained as to the true nature of the disease. For this fine preparation the museum stands indebted to Dr Moxon, of Guy's Hospital. Several of the liver cases are particularly instructive; but amongst the specimens presented by Mr Mitchell Henry is a small bottle full of minute hydatid vesicles, all of which were removed from the interior of the tibia. The history of this case has been lost; and, unfortunately, the bone from which the parasites were taken does not appear to have been preserved.

The museum connected with King's College contains at least a dozen good specimens of liver hydatids, several of the cases being of special interest from a pathological point of view. There are two remarkably fine examples of hydatids contributed by Dr Hooper, the parasites in one case affecting the spleen, and in the other involving the ovary and uterus. The spleen contained numerous encysted hydatids, whilst the uterine organs exhibited "an immense collection" of the same growths. In this place, also, I may refer to an hydatid-like entozoon, taken from a cyst in the ovary of a female who had been under the care of Dr Johnson (1860). It is, apparently, a genuine example of the slender-necked hydatid (*Cysticercus tenuicollis*); and if so (as might be determined by dissection), is, so far as I aware, the only specimen of the kind in existence

from the human bearer. There is a renal hydatid (presented by Dr Pass, of Warwick) which was obtained from a lunatic, its presence being "quite unsuspected during life." Amongst the liver cases (the majority of which are from Dr Hooper's collection), there is one enormous hydatid that was obtained from a young woman who had died during a fit of laughter. The tumour had pushed the diaphragm up to a level with the fourth rib; and it is stated that, on puncturing the cyst, the fluid contents were ejected "in a jet nearly two feet high." There is one case represented where numerous hydatids were expectorated after hepatitis, whence it was concluded that they were originally connected with the liver. There is a large solitary hydatid that was removed from a young female who died of phthisis, and in whom the consequent swelling had formed in the neighbourhood of the navel. Especially instructive, also, from a clinical point of view, is a case of peritoneal hydatids where the tumours had been diagnosed to represent a case of extra-uterine fœtation. It appears that there were two cysts, one of them being connected with the uterus. Two of the enormous hydatids taken from these cysts are preserved in the collection of the Anatomy School of Oxford. Several of the preparations show to perfection the stages of natural cure produced by calcareous degeneration; and there is one liver showing three of these so-called ossified cysts. The disease in this case proved fatal.

Most of the entozoa displayed in the Charing Cross Hospital Museum have been contributed by Dr Wiltshire, the series being particularly strong in tapeworms. There are four characteristic examples of hydatids of the liver, representing as many separate cases. Two were from abscesses of this organ. In one of these, Mr Canton's case, the hydatid was, I believe, expelled after operation; but in the other example (presented by Mr Rose, of Swaffham) the parasite was evacuated from an abscess, which burst of itself, externally.

In the museum at University College, I examined sixteen preparations of hydatid disease, representing almost as many distinct cases. One is a wax model. Eight of the specimens were from the liver, five from the abdomen (including those of the omentum and mesentery), two from the lungs, and one from the heart. The model displayed ordinary hydatids of the liver bursting into the lungs. The mesenteric example is particularly fine, whilst that from the omentum is undergoing cal-

careous degeneration. Probably the most interesting of all is the example showing an hydatid lodged in the septum of the heart. This was from a middle-aged female, who died suddenly whilst pursuing her ordinary domestic avocations.

The museum of the Royal College of Surgeons contains a fine collection of parasites, its chief strength in this respect being due to the special series of entozoa. Were visitors to judge by the contents of the catalogue of this series (which I prepared some years ago at the instance of the Council of the College), they might be led to suppose that the hydatids were only feebly represented. Out of nine preparations of hydatids in this section, only six have come from the human body. However, scattered throughout the collection, I found that there were no fewer than thirty-five preparations of hydatids belonging, apparently, to as many as thirty separate cases. Omitting, for the present, all mention of those derived from animals, I ascertained that, of the thirty human cases, thirteen were referable to the liver, four to the abdomen, three to the lungs (one of which was originally connected with the liver), and two to the brain. Five were of uncertain seat. With the abdominal cases we may also include one case of hydatids of the spleen, and another where these organisms were found in the region of the bladder. There is a characteristic breast case. One of the original Hunterian cases (in which "a prodigious number of hydatids were found in the sac of the liver and dispersed throughout the cavity of the abdomen") appears, though it is not expressly so stated in the catalogue, to have been regarded as an ordinary example of abdominal dropsy. In one of the three lung cases two small hydatids were separately expectorated at an interval of about a month. This occurred in a female.

I may here incidentally remark that many cases are on record where abdominal hydatids have been overlooked, the patient being supposed to be suffering from ascites. One such instance took place a few years ago at the Middlesex Hospital. I well remember a similar case of supposed hydrothorax, where the post-mortem examination revealed the presence of immense numbers of these formations occupying the right side of the chest. This case occurred at the Norfolk and Norwich Hospital, at the time when I was a student there, some thirty-five years ago.

The pathological collection connected with St George's

Hospital displays several good hydatid preparations, the entire series representing at least twenty-two separate cases. Of these, fifteen are referable to the liver, that is, if we include Dr Dickinson's case, already published, where hydatids were found within the hepatic duct. There are two renal cases; also one from the brain (Dr Dickinson's case), and another where an hydatid was expectorated. Besides these, there are three other highly characteristic examples of echinococcus disease affecting the region of the neck, breast, and axilla respectively.

The museum of the London Hospital Medical School contains a large collection of parasites. Out of fifty-seven preparations of entozoa, I found twenty-two referable to hydatids; and, so far as I could gather, all of them belonged to different cases. Only one case seems to have been published in detail. This, though a very old preparation, is a fine example of an hydatid, nearly three inches in length, occupying one of the cerebral hemispheres ('Edinb. Med. Journ.,' vol. xv). There is a second brain case, where the vesicles were of small size, but very numerous. Of the other twenty cases, fourteen belong to the liver, two to the spleen, one to the lung, one to the uterus; one being a very large hydatid of doubtful seat, and another being referable to the lumbar region, where it formed a tumour containing "a large number of small hydatids." Amongst the more remarkable specimens is that described in the MS. catalogue as "a true hydatid cyst developed in connection with the broad ligament." This preparation, unique of its kind, shows no trace of the ovary, which, indeed, seems to have disappeared altogether. One of the liver cases should rather be classed as abdominal, since the large cyst is situated between the diaphragm and liver, pressing upon the latter organ below and also upon the lung above, but apparently not involving either of these viscera structurally. Another very striking case is that in which there is an external opening communicating with the cyst in the liver, and an internal opening through the diaphragm communicating with the lungs and bronchial tubes. The patient had actually coughed up liver hydatids by the mouth, and had passed others through the right wall of his abdomen. There is another liver case in which the hydatids, in place of escaping externally, had gained access to the inferior cava; and if I understand the MS. record rightly, in the same patient a second hydatid communicated with the portal vein, and a third with the hepatic vein. Lastly, I must add that

there is yet another fine preparation of liver hydatids, occurring in a lad, nineteen years of age. He had, it seems, met with "a slight accident, and died with obscure head symptoms;" but the odd part of the case is that at the post-mortem examination there was positively nothing found that could explain the patient's death. He was under the care of Mr Luke (1834).

Comparatively recently I inspected the collection at St Thomas's Hospital, which I found to be particularly rich in entozoa of various kinds, especially tapeworms and hydatids. I encountered seventy-six preparations of internal parasites; and of these, forty-two were of the hydatid kind, representing at least thirty-three different cases. I say "at least," because it is often impossible to decide in instances where no history of the specimens can be obtained. Thus, there are three similar preparations of hydatids passed by the urethra, and, from their appearance, I judge them to have come from one and the same patient; yet there is no statement in the catalogue to that effect.

Of the thirty-three cases of hydatids represented in this museum, I reckoned eighteen as referable to the liver, two to the brain, two to the bones, two to the urinary organs, and one to the lung, spleen, uterus, and soft parts of the thigh respectively. There are also three that may be classed as peritoneal. There is another choice example in which the disease cannot be referred to any particular organ. I allude to Dr Peacock's case, already published ('Pathological Transactions,' vol. xv), where the lungs, liver, heart, spleen, and some other organs, were all occupied by hydatid formations. As an instance of extensive visceral infection by Echinococci in the human subject, I believe this case to be unique. The brain hydatids are particularly fine. In the specimen presented by Mr Boot, of Lincoln, the hydatid, two inches in diameter, is lodged in the anterior horn of the left ventricle. One of the peritoneal cases is remarkable for the amount of forward displacement of the pelvic viscera, caused by four or more hydatids, each of them nearly as large as a cricket-ball. Amongst the abdominal cases I have included a recent preparation, to which Mr Stewart has called my attention. The hydatid in question, of the size of a large lemon, existed near the fundus of the bladder, its walls being one third of an inch in thickness, and forming an unusually firm tumour. Of all the fine specimens of hydatids in the collection, however, none have struck me so much as those affect-

ing the bones. There is a humerus, taken from a man thirty-four years of age, in which the shaft is occupied throughout by small hydatids that have destroyed almost all the cancellous structure; in some places, also, the absorption of the cortical layer has gone on to such an extent as to have left little more than the periosteum. Of course, the bone was at last fractured easily. It is a beautiful specimen; and the existence of Echinococcus-heads was proved by microscopic evidence. Scarcely less interesting are two preparations illustrative of Mr Traver's case of a man, thirty-eight years of age, in whom numerous small hydatids occupied both the head of the tibia and the lower end of the femur. Each set of parasites freely communicated with the knee-joint, necessitating amputation of the limb.

The very large museum connected with Guy's Hospital is rich in hydatids. When, some time ago, I spent several days in going over the collection, I examined seventy-six preparations, representing apparently seventy separate cases of this affection. Amongst the noteworthy specimens one lung hydatid was intimately associated with a thoracic aneurism, two others being connected with the pleura; and of seven abdominal cases, five were connected with the peritoneum, one with the mesocolon, and one with the aorta. This last-mentioned instance occurred in a woman of sixty years, who, until her death, was treated for dropsy. She complained of incessant pain, which was only relieved when she rested on her hands and knees. Of the three cases affecting the heart one has been published (Mr Henderson's), where the patient, a girl of nineteen years, died suddenly whilst in the apparent enjoyment of perfect health. In one of the other two cases (Mr May's, of Tottenham), the left lung was also involved. One case of hydatid disease affecting the spinal column appears to have been originally an ordinary liver case. In Mr Cock's example of genuine mammary hydatids, the hooklets and echinoccocus heads were detected; but I am not sure that a similar result of microscopic examination was obtained in the equally interesting example of hydatids of the thyroid gland (also removed by Mr Cock). There are five bladder cases, all apparently genuine (of which one has been published); and there are also five other cases referred in the catalogue to the kidneys, of which I regard two as doubtfully parasitic in character. Of three cases of hydatid growths occupying the soft parts of the thigh, two were under Mr Bryant's care. The

museum likewise contains an old preparation of hydatids of the tibia, but its history has been lost. There are also two brain cases, besides upwards of a score of more or less characteristic and instructive cases of hydatids affecting the liver.

Scattered amongst the museums connected with the larger provincial schools and recognised hospitals there must be a great many valuable preparations of hydatid disease; at all events, I judge so from the inspection I have incidentally made of a few of the collections.

Of eleven preparations of human hydatids which I observed in the Cambridge Anatomical Museum, apparently representing the same number of cases, seven were connected with the liver and one with the lungs. Those hydatids displayed in the "special series" of entozoa were of uncertain seat. From the recently published and valuable 'Notes' by Dr Bradbury, I have no doubt that considerable additions have been made to the Cambridge Collection since my last visit.

The museum at Oxford contains some choice specimens of hydatids, but I have only personally inspected a few of them. In the absence of original notes, however, I am indebted to the kindness of Mr W. Hatchett Jackson for supplying me with several interesting particulars. The anatomical department of the Oxford Collection shows from one particular case two hydatids that were found "under the dura mater." In the pathological department we find one hydatid from the liver of a male subject, and also a preparation showing a number of small hydatids that were "coughed up from the lungs of a female." There are also in this department (Dr. Acland's) two examples of hydatids from the diaphragm, apparently belonging to two separate cases. One is described as a large "hydatid in the diaphragm covered by the pleura," whilst the other is spoken of as "springing from the diaphragm and projecting into the sac of the pericardium." There is likewise a preparation showing a number of small specimens of hydatids that were passed *per anum* by a female. It is conjectured that they came from the liver.

The small pathological museum attached to the Brighton and Sussex Hospital is particularly rich in hydatids. Amongst others, it contains preparations illustrative of the remarkable case of hydatids in the region of the prostate, communicated by Mr Lowdell, in the 'Lancet,' in 1846.

The comparatively large museum adjoining the Norfolk and

Norwich Hospital displays a choice series of hydatids, chiefly from the collection of the late Mr Crosse. That eminent surgeon prepared a special set of specimens to illustrate the process of natural cure by calcareous degeneration; and I may here, perhaps, be pardoned for mentioning that it was the study of these and other entozoa in Mr Crosse's Collection, some thirty or more years ago, that first drew my attention to the phenomena of parasitic life. Illustrations of the helminths in question are still in my possession. In one case (which is instructive as indicating the possibility of death from the simplest form and commonest habitat of an hydatid) a lad, twelve years old, received a slight blow from a playmate. Something gave way, and death speedily followed. It was found by post-mortem examination that a solitary liver hydatid, rather larger than a cricket-ball, had been ruptured. Although the case is almost unique, it is nevertheless by no means pleasant to reflect upon the fact that under similar circumstances a slight blow might prove fatal to any one, no matter in what internal organ the bladder worm happened to be situated.

Before concluding my summary notice of the human hydatids contained in the metropolitan and certain other museums, there is an interesting literary contribution that I cannot pass unnoticed. In the November number of the 'Indian Medical Gazette' for 1870 an article occurs in which it is stated that the Calcutta Medical College Museum contains eighteen specimens of hydatid cysts of liver. This fact was, it seems, originally adduced to show, not the frequency, but rather the rarity, of the occurrence of hydatids in India. However, from a valuable communication by Dr James Cleghorn, which was published in the same periodical for the following March, it appears that hydatids of the liver are much more common in India than is generally supposed. This, he says, is owing to the circumstance that many of the so-called cases of tropical abscess are neither more nor less than examples of hydatid cysts that have suppurated. Besides Cleghorn's evidence, we have the previous testimony of the Inspector General I. M. D., whose Report for 1868-69 I have already referred to in connection with *Cysticercus* in beef. He says: "During some three months' regular observation of the animals killed at the Commissariat slaughter-house here, at least 70 per cent. of the beef livers may be calculated as thus affected. Cobbold, writing of the *Tænia echinococcus*, says that 'this little tapeworm

infests only the dog and the wolf.' Therefore, considering the immense number of pariah dogs fed on the refuse of animals infected with hydatids, it seems more than probable that the parasite must attain its strobila condition in their intestines, and through them be eventually disseminated over the pastures on which the cattle graze."

I now turn to a neglected phase of the subject from which much practical instruction may be gathered. The consideration of the pathological phenomena of hydatid disease as it affects the lower animals is of high interest, and no prejudice should induce any medical man from accepting such useful data as may be gathered from this source. The facts of hydatid parasitism in animals, though often peculiar, are, for the most part, of an order similar to those presented in the human subject. If any medical practitioner thinks it beneath his dignity to study the pathology of the lower animals, the conduct of John Hunter in this respect is a standing protest against such narrowness.

The museum of the Royal College of Surgeons of England contains some of the finest specimens of hydatids from the lower animals that are to be seen anywhere, the very choicest of them having been selected by Hunter himself. That distinguished man sought information from every available source, and hydatids were for him of almost equal interest, whether found in the body of a human being or in the carcase of an ox or an ass. Now, at all events, neither pathologists nor sanitarians can well afford to neglect comparative pathology; and, for myself, I am free to say that the yearly exposition to the students of the Royal Veterinary College of the phenomena of parasitic life amongst animals has brought with it an ever-increasing knowledge of the most curious and often unlooked-for information. Some of the data thus supplied are quite remarkable. Let me also add that my studies of the entozoa of wild animals have put me in possession of particulars of high value in regard to the larger question of the origin of epidemics. Beasts, birds, reptiles and fishes, of every description, are liable to succumb to internal parasites, and there is practically no end to the variety of useful information to be obtained from this source. I have collected materials almost sufficient for a separate treatise on this department of the subject, but I fear I shall never have either the time or opportunity to give the facts due publicity. Here, for obvious reasons, I must for the most part restrict myself to the hydatids properly so called.

Referring, in the first instance, to the hydatids of animals that have the same mode of origin and exhibit the same general characteristics as those found in man, I notice that four of the metropolitan museums exhibit nine examples of liver Echinococci. The Hunterian Collection shows specimens of this kind from the pig, monkey, zebra, and lion. The museum at St Bartholomew's Hospital contains two examples from the pig and one from a cow ; whilst the animal liver-hydatids preserved in the King's College and Guy's Museums, respectively, are from the pig and sheep. That from the latter is partly calcified. Respecting animal hydatids affecting the lungs, the Cambridge Museum exhibits a simple acephalocyst from a monkey, and the Guy's Hospital Museum shows a pulmonary hydatid from the kangaroo. In the museum at Oxford, Dr Acland's (pathological) department shows a preparation of "one large echinococcus cyst from the abdomen of a baboon," whilst Dr Rolleston's department (anatomical) displays the echinococcus itself from the "cavity of the abdomen of the same animal." The collection also contains a variety of other bladder worms from different animals. The Hunterian Museum, Lincoln's Inn, exhibits four or five alleged examples of hydatids from the kidney of the sheep, besides another from the spleen. Some of these are of very doubtful character. A cystic kidney from the sheep, preserved in the London Hospital Museum, and originally supposed to have been due to hydatids, is (as hinted in the MS. catalogue) certainly not of parasitic origin. In regard to the occurrence of hydatids in the heart of animals the Hunterian series shows two good examples from cattle, whilst the collection at University College exhibits one taken from the wall of the left ventricle of a sow. This was presented by Dr Elliotson.

In the museum of the Royal Veterinary College there are a number of excellent preparations of true hydatids taken from various animals, especially from cattle, swine, and sheep ; and there are also many kinds of bladder worms which, though often called "hydatid" by veterinarians, have a totally different origin from that of the true Echinococci. The so-called gid-hydatids (Cœnuri) and slender-necked hydatids (*Cysticercus tenuicollis*) are of this description. Specimens of the polycephalous brain hydatid, or Cœnurus, also exist in the museums connected with St Bartholomew's, Guy's, and St Thomas's Hospital Medical Colleges, as well as in both the anatomical

and pathological departments of the Oxford Museum. Specimens of large Cœnuri occurring in the soft parts of rabbits may be seen in the Guy's Museum (presented by Mr Carpenter). Similar characteristic specimens exist in the Oxford Collection, labelled *C. cuniculi*, obtained from the "masseter and infra-spinatus" muscles of a rabbit. My private collection also contains a recent addition of this remarkable hydatid, sent to me by Mr Alston from Ayrshire. It is the only one I have seen from Scotland. In the second half of this work these Cœnuri will again come under notice. Three examples of the slender-necked hydatid (from a monkey and two sheep respectively) may be seen in the Guy's and University College Collections, and there are several in the museum of the Royal Veterinary College.

I cannot go out of my way to speak of other bladder worms, except so far as to call attention to the heart of a bear preserved in the museum at Guy's, the walls of which are crowded with Cysticerci. That unique preparation ought to be carefully examined and described. The Hunterian Museum contains two magnificent specimens of hydatids affecting the bones of cattle. In the one case a solitary vesicle occupies the shaft of the humerus; whilst in the other several "acephalocysts" have taken up their residence within the cancellous structure of the ilium.

In the matter of human mortality from hydatids I have already supplied statistical evidence of the unenviable distinction which our Australian colonies exhibit, and in addition to the facts brought forward I may add that Dr Lewellin has mentioned to me a fatal case in which an hydatid occupied the whole length of the vertebral canal. The patient was under Dr Annand's care. There could be no doubt as to the genuineness of the case, as the spinal cyst was tapped during life, when echinococcus hooklets were found.

Through Dr Lewellin I am also indebted to Dr H. B. Allen, pathologist at the Melbourne Hospital, for the particulars of a case of hydatids of the cerebrum, which are given as follows :

"J. Q—, aged 15, was admitted into the Melbourne Hospital on the 13th November, 1877, suffering from partial left hemiplegia. He rapidly became insensible and died next day. His mother furnished the following history.

"He had been woodcarting in the bush for a considerable

time, and while thus engaged eight weeks before admission began to lose power in his left arm and leg; gradually the paralysis increased, and he was taken home, where he remained for six weeks. During this time he had every week an attack of severe headache, and once he lost all sight for over half an hour. Gradually the symptoms increased, and he was taken to the hospital, but even then was able to walk with assistance part of the way.

"At the autopsy, when the calvarium was removed, a large cyst about four inches in diameter was found on the mid-convexity of the right hemisphere of the cerebrum, slightly towards its anterior part. It formed a marked prominence on the anterior surface of the brain, and was bounded superficially by the pia mater and arachnoid, which were neither noticeably thickened nor adherent to the dura mater. On opening the cyst it was seen to extend inwards and abut on the wall of the lateral ventricle, and consisted of the ordinary gelatinous membrane, studded internally with little granular eminences, some pellucid, some opaque white. The contents were thin limpid fluid. The brain tissues around presented scarcely any induration. All other organs structurally healthy, congestion being the only morbid condition present.

"The specimen is preserved in the hospital museum, which contains two other preparations of hydatids in the brain, and also an hydatid cyst of large size growing from the interior of the frontal bone."

In concluding this account of hydatids I may remark that, by the employment of sanitary measures, the disorder might, in course of time, be thoroughly stamped out. What these measures are I have already stated.

I need hardly say that the following bibliography by no means exhausts the records of echinococcus disease. In Dr Albert Neisser's recent monograph nearly a thousand separate cases are quoted and classified. The monograph of Dr Hearn, which is not mentioned in Neisser's work, also contains a valuable bibliography.

English literature. *Hydatids in general* (Bibliography No. 20 *a*).—*Ballard, E.* (review of Henoch), 'Med.-Chir. Rev.,' 1854.—*Bird, S. D.*, 'On Hydatids of the Lung; their diagnosis, prognosis, and treatment,' 2nd edit., Melbourne, 1877.—*Busk*, "On the Nat. Hist. of the Echinococcus," 'Micr. Soc. Trans.,' orig. series, vol. ii, 1849.—*Budd, G.*, 'Diseases of the Liver,'

Lond., 1845.—*Carmichael, R.* (lecture), 'Dub. Med. Press,' 1840, p. 91.—*Cobbold, T. S.*, 'Entozoa,' chap. vii and viii, 1864.——*Idem*, "On Hydatid Disease" (lecture), 'Lancet,' June, 1875, p. 850.—*Idem*, "On Hydatid Diseases of Man and Animals" (museum specimens), in a series of articles contributed to 'Brit. Med. Journ.,' Oct., 1875, to Jan., 1876; fully reprinted in the 'Veterinarian,' Feb., 1876.—*Copland, J.* (Art. "Hydatids") in his 'Dictionary,' 1848.—*Davies, T.*, 'Lond. Med. Gaz.,' 1835.—*Gairdner, J.*, and *Lee*, 'Edinb. Med. and Surg. Journ.,' 1844.—*Goodsir, H. S. D.* (same ref., Lee's case), 1844.—*Goodsir, J.* (same ref.), 1844.—*Gross, S. D.*, 'Elements of Path. Anat.,' chap. xv, Boston, U.S., 1839.—*Hawkins, C.*, 'Lancet,' 1833.—*Hjaltelin*, 'Edinb. Med. Journ.,' 1867; see also Dobell's 'Report on the Progress of Practical and Scientific Medicine,' London, 1870.—*Hodgkin, T.*, in his 'Lectures on the Serous and Mucous Membrane,' 1838.—*Kerr, W.* (art. "Hydatids") 'Cyclop. of Pract. Med.,' 1833.—*Leared, A.* (prevention), 'Med. Times and Gaz.,' 1863.—*MacGillivray, P. H.* (see below, miscell. cases).—*Murchison C.*, in his 'Clinical Lectures,' Lond., 1868, p. 54; 2nd edit., 1877.—*Idem*, "Hydatid Tumours of the Liver; their danger, their diagnosis, and their treatment," 'Edinb. Med. Journ.,' 1865.—*Nettleship, E.*, "Notes on the Rearing of *Tænia echinococcus* in the Dog from Hydatids, &c.," 'Proc. Royal Soc.,' 1866, p. 224.—*Rose, C. B.*, "On the Vesicular Entozoa, and particularly Hydatids," 'Lond. Med. Gaz.,' 1833-4, p. 204.—*Stephens*, 'Lancet,' 1833; the 'Veterinarian,' 1831, p. 284.—*Thompson, T.* (remarks), 'Lancet,' 1851.—*Wilson E.*, "On the Structure, Classification, and Development of the *Echinococcus hominis*," 'Med.-Chir. Trans.,' 1845.—*Yates, G.*, "On Hydatid Disease," 'Assoc. Med. Journ.,' vol. iii, 1855.

Hydatids of the liver (BIBLIOGRAPHY No. 20 *b*).—*Abercrombie, T.*, 'Lond. Med. Journ.,' vol. ii, p. 276, 1829.—*Alison, S. S.*, 'Lond .Med. Gaz.,' 1844.—*Barclay*, 'Brit. Med. Journ.,' Nov., 1868, p. 494.—*Barker, T. A.* 'Lancet,' and 'Path. Soc. Trans.' 1855.—*Barlow*, 'Lond. Med. Gaz.,' 1857.—*Beith*, 'Path. Soc. Trans.,' 1852.—*Bradbury, J. B.* (six cases), 'Brit. Med. Journ.,' Oct., 1874, pp. 526-558.—*Idem*, 'Brit. Med. Journ.,' 1876, vol. ii, p. 646.—*Brinton*, 'Lancet,' 1854.—*Idem*, 'Lancet,' 1858.—*Bristowe, T. S.*, 'Path. Soc. Trans.,' 1851.—*Idem*, 'Path. Soc. Trans.,' 1858.—*Broadbent, W. H.*, "Hydatids of the Liver; Paracentesis followed by free Incision;" 'British

Med. Journ.,' Nov. 30th, 1878.—*Brodie, B. C.* (supposed), 'Lond. Med. Gaz.,' 1828.—*Brook, C.*, 'Lancet.,' Feb., 1868, p. 162.—*Buchanan*, 'Surg. Med. Gaz.,' 1861.—*Budd, W.*, 'Brit. Med. Journ.,' 1859.—*Chambers, T. K.*, 'Lond. Med. Gaz.,' 1846.—*Cox, T.*, 'Lancet,' and 'Med-Chir. Trans.,' 1838.—*Crosse, J. G.*, 'Lancet,' 1837.—*Curling T. B.*, 'Med.-Chir. Trans.,' 1840.—*Daly, O.* (supposed), 'Brit. Med. Journ.,' 1859. —*Davies H.*, 'Path. Soc. Trans.,' 1848.—*Dickenson*, 'Lond. Med. Gaz.,' 1861; 'Path. Soc. Trans.,' 1862.—*Duncan, A.* (near the portal vein), 'Edin. Med. and Surg. Journ.,' 1808.—*Duncan, P. M.* (several cases), 'Prov. Med. and Surg. Journ.,' 1850-52 *Elliotson, J.*, 'Lancet,' 1832.—*Fearn, S. W.* (immense cyst), 'Brit. Med. Journ.,' Nov., 1868, p. 496.—*Fletcher, T. B. E.*, 'Prov. Med. and Surg. Journ.,' 1846.—*Freer, W. G.*, 'Lancet,' and 'Prov. Med. and Surg. Journ.,' 1845.—*Gaitskell, W.* (1000 discharged) 'Lond. Med. Repository,' 1815.—*Gulland*, 'Edin. Med. Journ.,' 1860.—*Harley, J.*, 'Lancet,' May, 1866, p. 538, and 'Med. Chir. Trans.,' 1866.—*Idem*, in 'St Thomas's Hospital Reports,' 1877, p. 291.—*Hastings, C.*, 'Brit. Med. Journ.,' 1858.—*Heaton*, 'Brit. Med. Journ.,' Oct. 31st, 1874, p. 557.—*Heckford, N.*, 'Brit. Med. Journ.,' Sept., 1868, p. 332.—*Hillier*, 'Lancet,' and 'Path. Soc. Trans.,' 1855.—*Hutchinson, J.*, 'Lancet,' Oct., 1862.—*Inglis, A.*, 'Brit. Med. Journ.,' 1859.—*Leared A.* (Hjaltelm's case), 'Path. Soc. Trans.,' 1863.—*Logan* (thousands present), 'Path. Soc. Trans.,' and 'Med. Times and Gaz.,' March, 1865, p. 243.—*Lyon, E.* (several cases), 'Prov. Med. and Surg. Journ.,' 1850.—*Murchison, C.* (rupture through pleura), 'Path. Soc. Trans.,' 1861.—*Idem*, 'Lancet,' July, p. 75, 1868.—*Page*, 'Brit. Med. Journ.,' and 'Lancet,' Nov., 1864.—*Pavy, F. W.* (expectorated), 'Med. Gaz.,' 1851.—*Idem*, 'Med.-Chir. Trans.,' and 'Lancet,' Sept., 1866, p. 234.—*Peacock* (two cases, expectorated), 'Lond. Med. Gaz.,' and 'Lancet,' 1850.—*Pemberton, O. A.* (rupturing diaphragm), 'Prov. Med. Journ.,' 1848.—*Philipson*, 'Brit. Med. Journ.,' Oct. 31st, 1874, p. 557.—*Pollock, J.* (fatal), 'Path. Soc. Trans.,' 1854.—*Idem* (opening into lung), 'Lancet,' Jan., 1865, p. 63.—*Rees, G. O.*, 'Guy's Hosp. Rep.,' 1848.—*Idem* (lecture), 'Lond. Med. Gaz.,' 1849.—*Richards, C. C.*, 'Lancet,' Jan., 1865, p. 261.—*Roberts*, 'Lancet,' 1833.—*Russell, J.*, 'Prov. Med. and Surg. Journ.,' 1851.—*Sadler, M. T.* (Cæsarean section), 'Med. Times and Gaz.,' Aug., 1864, p. 141.—*Salter, H.*, 'Path. Soc. Trans.,' 1860.—*Savory, W. S.* (letter), 'Lancet,' May, 1866,

p. 410.—*Sherwin, H. C.* (fatal), 'Edin. Med. and Surg. Journ.,' 1823.—*Sibson, F.*, 'Lancet,' July, 1868, p. 76.—*Sloane, J.* (puncture), 'Brit. Med. Journ.,' 1858.—*Thompson H.*, 'Path. Soc. Trans.,' and 'Lancet,' 1858.—*Trimnell, G. C.*, 'Lond. Med. Repos.,' 1821.—*Ward, S. H.*, 'Lancet,' 1868, vol. ii, pp. 141, 305, and 474.—*Wearne, V.* (perforating diaphragm), 'Brit. Med. Journ.,' July, 1864, p. 31.—*Wilks* (escaping by gall-ducts), 'Path. Soc. Trans.,' 1860. — *Young, J.*, 'Edin. Med. and Surg. Journ.,' 1829.

Hydatids of the liver and other organs together (BIBLIOGRAPHY No. 20 *c*).—*Beale, L.* (kidney), 'Arch. of Med.,' vol. i, p. 31, 1857; see also same case by *Bristowe*, 'Path. Soc. Trans.,' 1853.—*Billing* (lungs), 'Lond. M. and S. Journ.,' 1831, p. 58. —*Griffith, J. W.* (abdomen), 'Lond. Med. Gaz.,' 1844.—*Heslop, T. P.* (kidney), 'Month. Journ. of Med. Sci.,' 1850.—*Richardson* (kidney, Dr Mackinder's case), 'Lancet,' 1855.

Liver cases occurring in America (BIBLIOGRAPHY No. 20 *d*).—*Alexander, E.* (200 present), 'Boston Med. and Surg. Journ.,' 1838.—*Finnell*, 'New York Med. Journ.,' 1856, p. 216.—*Minot, T.* (expectorated), Bost. Soc. for Med. Improv., 1859, and 'Brit. Med. and Surg. Journ.,' 1860, p. 297.—*Webber, J. E.*, 'New York Med. Times,' 1853, and 'Bost. Med. and Surg. Journ.,' 1853, p. 126.

Hydatids of the lungs and pleura (BIBLIOGRAPHY No. 20 *e*).—*Cholmeley*, 'Guy's Hosp. Rep.,' 1837.—*Dowling, F.*, 'Australian Med. Journ.,' 1864.—*Duffin, A. B.*, 'Beale's Archives,' 1857, vol. i, p. 253.—*Hare*, 'Path. Soc. Trans.,' 1857-8.—*Hill, J.*, 'Med. and Philos. Comm.,' 1784, vol. ii, p. 303.—*Hutchinson, J.*, 'Path. Soc. Trans.,' 1854.—*Kirkes, W. S.*, 'Med. Times and Gaz.,' 1851.—*Leared, A.*, 'Path. Soc. Trans.,' 1857.—*Peacock*, 'Lancet,' 1850.—*Ridge, J.*, 'Guy's Hosp. Rep.,' 1836, p. 507.—*Rigden, G.*, 'Prov. Med. and Surg. Journ.,' 1852.—*Smith, F. G.*, 'North Amer. Med.-Chir. Rev.,' 1858, p. 333.—*Todd, R. B.*, 'Med. Times and Gaz.,' 1852.

Hydatids of the Kidney (BIBLIOGRAPHY No. 20 *f*.)—*Adams, A. L.*, 'Lancet,' 1864, p. 375.—*Barker, T. H.*, 'Glasg. Med. Journ.,' 1855-6, p. 439.—*Duncan*, 'Liverpool Med. Journ.,' 1834.—*Dunn, J.*, 'Lond. Med. Repos.,' 1817.—*Fussell, E. F.*, 'Lancet,' 1851.—*Lettsom* (two cases), 'Trans. Med. Soc. of Lond.,' 1789, p. 33.—*Ward, W.*, 'Lancet,' 1846.—*Wilson, J.* (lecture) 'Lond. Med. Repos.,' 1822.

Hydatids of the spleen, omentum, and abdominal cavity

(BIBLIOGRAPHY No. 20 *g.*).—(Anonymous), 'Edin. Med. and Surg. Journ.,' 1819, p. 50.—*Bailey, F.*, 'Lond. Med. Repos.,' 1826.—*Bright, R.* (remarks on cases) 'Guy's Hosp. Rep.,' 1838.—*Bryant, T.* (simulating ovarian disease), 'Guy's Hosp. Rep.,' 1868, p. 235.—*Budd, G.* (omentum), 'Med. Times,' 1838.—*Idem* (rep. by Parsons), 'Brit. Med. Journ.,' 1859.—*Burman*, 'Prov. Med. Journ.,' 1847.—*Crowther, C.*, 'Edin. Med. and Surg. Journ.,' 1826, p. 49.—*Greenhow, E. H.*, 'Lancet,' 1862.—*Little, W. I.* (simulating ovarian disease), 'Brit. Med. Journ.,' 1857.—*Macleay, K.*, 'Edin. Med. and Surg. Journ.,' 1806.—*Morley, J.* (partly pelvic), 'Lancet,' 1845.—*Newman, W.* (simulating ovarian disease), 'Obstetr. Soc. Trans.,' vol. iv, 1862.—*Obre* (peritoneal), 'Path. Soc. Trans.,' 1854.—*Ogle, J.* (omentum), 'Path. Soc. Trans.,' 1860.—*Simpson, A. R.* (peritoneal), 'Edin. Med. Journ.,' 1861-62.—*Simpson, J. Y.*, 'Assoc. Med. Journ.,' 1854, p. 137.—*Thompson, T.*, 'Lancet, 1843.—*Thompson, A. T.* (simulating ovarian disease), 'Lancet,' 1833.

Hydatids within the pelvic cavity (BIBLIOGRAPHY No. 20 *h*).—*Birkett, J.* (voided), 'Guy's Hosp. Rep.,' 1851, p. 300.—*Bryant, T.*, 'Lancet,' 1865, pp. 566 and 589.—*Corrigan* (ovarian), 'Dub. Quart. Journ.,' vol. i, 1846.—*Crampton* (ovarian), 'Dub. Quart. Journ.,' vol. ii, 1846.—*Curling, T. B.* (bladder), 'Med. Times and Gaz.,' 1863.—*Farre, A.*, 'Lancet,' 1862.—*Habershon*, 'Path. Soc. Trans.,' 1860.—*Hughes*, 'Lond. Med. Gaz.,' 1861.—*Hunter, T.*, 'Trans. of Soc. for Improv. of Med. and Chir. Knowledge,' 1793, p. 34.—*Jennings* (simulating pregnancy), 'Dublin Quart. Journ.,' 1855.—*Lowdell*, 'Lancet,' 1846.—*Maunder*, 'Lancet,' Sept., 1864, p. 351.—*Sadler, M. T.* (voided), 'Med. Times and Gaz.' 1865.—*Simon, J.* (voided), 'Lancet,' 1853.—*Wakley*, 'Lancet,' 1863.—*White*, 'Med. Gaz.,' 1842.

Hydatids of the heart and blood-vessels (BIBLLIOGRAPHY No. 20 *i*).—*Bigger*, 'Dub. Path. Soc.' Rep. in 'Lancet,' 1830.—*Budd, G.*, 'Path. Soc. Trans.,' 1839.—*Coote, H.*, 'Lond. Med. Gaz.,' 1854.—*Goodhart*, 'Brit. Med. Journ., Nov. 27, 1875.—*Price, D.*, 'Lond. Med. Repos.,' 1822.—*Smith, R.*, 'Lancet,' 1838.—*Trotter*, 'Chem. and Med. Essays,' 1736.—*Wilks* (Henderson's case), 'Path. Soc. Trans.,' 1860.

Hydatids of the brain and cranial cavity (BIBLIOGRAPHY, No. 20 *k*).—(Anonymous) 'Lancet,' April, 1864, p. 444.—*Bailey, F.*, 'Lancet,' 1825 ; 'Lond. Med. Repos.,' 1826.—*Barker, T. A.*, 'Path. Soc. Trans.,' 1858.—*Bennett, J. R.*, 'Med. Times and Gaz.,' Jan., 1862.—*Berncastle, J.*, 'Lancet,' 1846.—*Bree, C. R.*, 'Lan-

cet,' 1837.—*Brittan, F.*, 'Brit. Med Journ.,' 1859.—*Burton*, 'Med. Times and Gaz.,' 1862.—*Dagleish, G.*, 'Lancet,' 1832.—*Fletcher, T. B. E.*, 'Assoc. Med. Journ.,' vol. iii, p. 161, 1855.—*Headington*, 'Edin. Med. and Surg. Journ.,' vol. xv, 1819, p. 504.—*Helsham*, 'Med. Comment.,' vol. xiii, 1788, p. 289.—*Macnamara, W. H.*, 'Brit. Med. Journ.,' vol. ii, p. 616, 1876.—*Rigden, G.*, 'Prov. Med. and Surg. Journ.,' 1852.—*Stewart, J.*, 'Lancet,' 1848.—*Sturton*, 'Lancet,' 1840.—*Wilson, E.*, 'Lancet,' 1848.

Hydatids of the bones (BIBLIOGRAPHY No. 20 *l*).—*Cobbold, T. S.*, "Notice of Specimens of Tibial Hydatids in Nottingham," 'Brit. Med. Journ.,' 1865, and in the 'Veterinarian,' Feb., 1866.—*Idem*, "Notice of Specimens from the Tibia in the Mid. Hosp. Museum," *ibid.*—*Cooper, A.*, "Foster and Lucas's case affecting the Tibia," 'Surg. Essays,' Lond., 1818.—*Coulson, W.* (tibia), 'Med.-Chir. Trans.,' 1858; see also *Daubeny, H.*, 'Path. Soc. Trans.,' 1858.—*Erichsen, J. E.*, in his 'Surgery,' 4th edit., pp. 728, 823, and 948, Lond., 1864.—*Hunter, W.* (tibial, Mus. Spec. at Glasgow), quoted in 'L'Expérience,' 1838, p. 531.—*Keate, R.* (os frontis), 'Med.-Chir. Trans.,' 1819.—*Lambert, J.* (tibia), 'Lancet,' 1826.—*Thompson, H.* (Hearne's tibial case), 'Path. Soc. Trans.,' 1859.—*Webster, F. W.* (tibia), 'New Eng. Med. Journ. of Med. and Surg.,' 1819.—*Wickham, W. J.* (tibia), 'Lond. Med. and Phys. Journ.,' 1827.

Hydatids of the breast, muscles, and soft parts (BIBLIOGRAPHY No. 20 *m*).—*Adams, J.* (abdominal parietes), 'Lancet,' 1851.—(Anonymous), "Hyd. in the Eye of a Girl," 'Boston Med. and Surg. Journ.,' 1849, p. 28.—*Baird, J.* (muscles), 'Edin. Med. and Surg. Journ.,' 1821.—*Birkett, J.* (mammary), 'Lancet,' March, 1867, p. 263.—*Brodie, B. C.* (near scapula), 'Lancet,' 1818.—*Bryant, T.* (thigh), 'Path. Soc. Trans.,' 1859.—*Idem* (thigh), 'Lancet,' 1862.—*Idem* (breast), 'Path. Soc. Trans.,' and 'Lancet,' Nov., 1865, p. 565.—*Cholmeley* (from right side), 'Lancet,' 1826.—*Cooper, B. B.* (neck and breast, two cases), 'Guy's Hosp. Rep.' 1851.—*Idem*, in Birkett's work on the 'Breast,' p. 183; the 'Institute,' vol. i. p. 119, 1850.—*Dixon, J.* (neck), 'Lancet,' 1851.—*Henry, M.* (breast), 'Lancet,' Nov., 1861, p. 497.—*Hewndon, A.* (neck), by Tyson, in 'Phil. Trans.,' 1706-7, vol. xxv, p. 2344.—*Jones, S.* (subperitoneal), 'Path. Soc. Trans.,' 1854.—*Rankine, J.*, "Supposed Hyd. in Synovial Sheaths," 'Edin. M. and S. Journ.,' 1830.—*Sands* (neck), 'Amer. Med. Times,' 1861, vol. ii, p. 376.—*White* (breast and arm), 'Lancet,' 1839.

Hydatids of uncertain seat, or miscellaneous cases and observations (Bibliography No. 20 *n*).—*Barrett*, 'Lond. Med. Gaz.,' 1838.—*Durrant, C. M.* (Ipswich Hosp.), 'Prov. Med. and Surg. Journ.,' 1851.—*Fagge, H.*, 'Lancet,' July, 1868, p. 76.—*Greenhow, J. M.* (intestinal), 'Lancet,' 1823.—*Howship, J.* (case, with speculative remarks), 'Edin. M. and S. Journ.,' 1835.—*MacGillivray, P. H.* (orbit, &c.), 'Austral. Med. Journ.,' Aug., 1865.—*Idem, ibid.*, March, 1867.—*Idem* (3rd series of cases), *ibid.*, July, 1872.—*Idem* (treatment with kamala), *ibid.*, July, 1872.—*Markham, W. O.*, "On the 'son hydatique,'" 'Assoc. Med. Journ.,' 1856, p. 1072.—*Musgrave* (letter to Sir H. Sloane), 'Phil. Trans.,' vol. xxiv, 1704-5.—*Phillips*, 'Lancet,' July, 1868, p. 77.—*Russell, J J.*, 'Dub. Journ.,' 1838.—*Salter, H.*, 'Path. Soc. Trans.,' 1854.—*Ward, T. O.*, 'Lond. Med. Gaz.,' 1837.

Hydatids of animals (*acephalocysts*) (Bibliography No. 20 *o*).—*Böllinger* (see Bibl. No. 49).—*Cobbold*, 'Manual,' l. c. (Bibl. No. 2), 1874.—*Crisp, E.* (in a turkey and in hogs), 'Path. Soc. Trans.,' 1863.—*East, J.* (see Steel).—*Findeisen*, "Echin. in der Lunge," 'Repertorium für Thierheilkund.,' 1875, s. 48.—*Gross, S. D.* (in swine), 'Elements of Path. Anat.,' 1845, p. 118.—*Hunter, J.*, "A Cyst (hydatid) which was filled with water, formed in and filling up the Bone (humerus) of an Ox (from Hunterian MS.)," more fully described in the 'Catalogue of the Mus. Lond. Coll. Surg.,' "Path.," vol. ii, prep. No. 864, p. 201, 1847.—*Idem*, "On Hydatids in Sheep" (supp. to Trans. of a Soc., l. c., *supra*), 1793.—*Hutchinson, J.*, "Hydatid in the Eye of a Horse," 'Path. Soc. Trans.,' and 'Lancet,' 1857.—*Huxley, T. H.*, "On the Anatomy and Development of *Echinoc. veterinorum* (from a Zebra)," 'Proc. Zool. Soc.,' 1852.—*Kirkman, J.*, "Chronic Disease of the Bones of the Cranium of a Horse, associated with the existence of Hydatids within a Cyst at the inferior part of the Orbit," the 'Veterinarian,' vol. xxxvi, p. 77, 1863.—*Lepper*, "Hydatids in the Kidney of a Lamb," the 'Veterinarian,' 1863, p. 524.—*Martin, J.* (in the liver of a sow), 'Vet. Assoc. Trans.,' 1842-3, pp. 330 and 364.—*Moorcroft, W.* (in the brain of a cow), 'Med. Facts and Observ.,' vol. iii, 1792.— *Morgan, A.* (in the brain of a mare), the 'Veterinarian,' 1855, p. 396.—*Peech, S.* (in the muscles of a horse), the 'Veterinarian,' 1854, pp. 80 and 209. —*Siedamagrotzky* (see Bibliog. No. 49).—*Simonds, J. B.*, "Remarks on Mr. Scruby's case of Hydatids in the Liver of a

Sheep," 'Trans. of Vet. Assoc.,' 1842-3, p. 331.—*Steel, J. H.* (in liver of a cow; Mr East's case), the 'Veterinarian, 1878, p. 441.—*Stoddart* (in liver of a cow), the 'Veterinarian,' 1838, p. 637.—*Thudichum, J. L. W.* (in sheep), 'Assoc. Med. Journ.,' 1856, p. 195.—*Vincent, J. P.* (in horse, causing lameness), the 'Veterinarian,' 1848, p. 674.—*Walker, A.* (in the liver of a sow), 'Vet. Record,' 1846, p. 185.—*Woodger* (in the brain of a horse), the 'Veterinarian,' 1863, p. 75.

Foreign Literature. Human Hydatids (Bibliography No. 20 *p*).—*Böcker*, 'Zur statistik der Echinoc.,' Berlin, 1868.—*Davaine, C.*, 'Traité' (l. c., Bibl. No. 1), p. 350, 1860; 2nd edit. p. 369, 1877.—*Idem*, "Recherches sur les hydatides, les échinoc., &c.," 'Gaz. Méd. de Paris,' 1855.—*Idem*, "Recherch. sur le frémissement hydatique," 'Gaz. Med.,' 1862.—*Eschricht*, 'Danske videnskab. selsk. forhandl.,' 1853.—*Finsen*, 'Ugeskrift for Läger,' Bd. iii, 1867; see also 'Brit. and For. Med.-Chir. Rev.,' 1868, p. 324; also 'Schmidt's Jahrb. für Med.,' 1867, s. 181.—*Guérault*, "Sur la maladie hydatique, &c.," 'Gaz. des Hôp.,' 1857.—*Hearn, A. W.*, 'Kystes hydatiques du poumon et de la plèvre,' Paris, 1875.—*Heller, A.*, "Die Schmarotzer der Leber," von 'Ziemssen's 'Handbuch d. Spec. Pathol. und Therapie,' Bd. viii, s. 559.—*Krabbe, H.*, "Maladie causée en Island par les Échinocoques," in his 'Recherches Helminthologiques,' p. 41, Paris, 1866; 'Helm. Undersøgelser,' Copenhagen, 1865, p. 40.—*Idem*, 'Die echinoc. der Islander," 'Archiv für Naturg.,' 1865, and in 'Den med. Skole i Reykjavik,' 1868.—*Idem* (see T. R. Jones, Bibl. No. 2).—*Leuckart, R.* (l. c., Bibl. No. 1), Bd. i, s. 335, 1863; Bd. ii, s. 859, 1876.—*Linder*, 'Echinococcen der Leber,' Leipsic, 1869.—*Naunyn*, 'Archiv für Anat., Physiol.,' &c., 1862-3.—*Neisser, A.*, 'Die echinococcen Krankheit.,' Berlin, 1877.—*Rassmussen*, 'Bidrag til Kundskab om Echinoc.,' &c., 1865; see also 'Brit. and For. Med.-Chir. Rev.,' 1866, p. 285, and 1867, p. 424.—*Schmalfuss*, 'Ueber Leberechinococcus,' Breslau, 1868.—*Tommasi, T.*, 'Storia di un caso di Echinoc.,' &c., in an appendix (Nota) to his edition of my 'Lectures' (Vermi, &c.), Milan, 1873, p. 153.

Note.—As Leuckart, Davaine, and especially Neisser offer exhaustive analyses of the French and German literature of human hydatids, I will only give the authors' names attached to such additional foreign memoirs and cases as have been published in England. These are quoted in my 'Introductory Treatise on the Entozoa.' Full references will be found in the

"Bibliography" of that work under the following heads:—*Andral* (pulmonary veins), *Angeli, Auglagnier* (bladder), *Baillarger* (brain), *Boinet* (liver), *Chaubasse* (abdominal), *Cruveilhier* (liver and spleen), *Dupuy* (hydatids in animals), *Demarquay* (liver), *Dupuytren* (muscles and viscera, &c.), *Fouquier* (lungs), *Gayet* (liver), *Goyrand* (liver), *Guérard, Guillot, Hedinger* (brain), *Heintz* (liver), *Held* (thigh), *Heller* (lip), *Klencke* (blood, &c.), *Kuhn, Lafforgue* (liver), *Legroux, Livois, Luschka* (liver), *Martinet* (brain, liver), *Maug* (hand), *Meissner, Micheá* (brain), *Moissenet* (liver), *Montault* (brain), *Morrisseau, Nicolai* (liver), *Oerstelen* (kidney), *Pohl* (abdominal), *Quinquirez* (bladder), *Récamier* (abdominal), *Richard* (liver), *Roget* (lungs), *Roux* (pelvic), *Rüttel* (brain), *Schleissner, Sichel, Sömmering* (eye), *Skoda, Tomowitz* (bladder), *Zeder* (brain).

Additional references to the echinococcus disease as it occurs in animals will be found at the close of the section devoted to the parasites of Ruminants (Bibliography No. 49), and I shall recur to the subject of mortality from "worms" further on.

SECTION III.—Nematoda (Round Worms).

Trichina spiralis, Owen.—The progressive triumphs of biological science are well epitomised in the history of the discovery, and in the record of the gradual manner in which we have obtained our present complete knowledge of the structure and development of this small entozoon.

Although the facts connected with the original discovery are clear and indisputable, much error still pervades foreign literature on this head. Without a doubt Mr Hilton was the first to suggest the parasitic nature of the capsules first spoken of as "gritty particles." With Sir James Paget, however, rests the true discovery and determination of the nematoid character of the worm itself. With Professor Owen remains the honor of having first scientifically verified, described, and named the entozoon. Some have sought, without good reason, to alter Owen's nomenclature; yet not only the generic title, but nearly all else that he wrote concerning the parasite, must be allowed to stand.

In relation to the capsules, it is true that prior claims of discovery have been put forward; but whilst Peacock's preparation of the "little bodies" testifies to the fact of his having

seen the capsules before other English observers, including Wormald, it was Hilton who first surmised their parasitic character. As for the claims of Klencke and Tiedemann, they are practically of no value, even if it be admitted that the former may have at an early period seen something resembling this nematode, and that the "stony concretions" encountered by the latter were degenerated capsules.

On no subject have I desired to write with more accuracy and precision than on this, and lest the above remarks should appear to be somewhat partial, I now purposely re-state the facts as they have presented themselves to me during a full and prolonged study of the entire literature of the subject. If it be asked with whom rests the discovery of *Trichina*, the reply must be framed with a due regard to precise issue at stake. The first recognition of the capsules as parasitic products is fairly claimed by Hilton; the worm by Paget; the zoological allocation and nomenclature by Owen; the adult worm by Virchow; the developmental phenomena by Leuckart; the rearing of the larvæ by Herbst; and to crown all, the clinical importance of the parasite by Zenker. Due regard being had to these relative claims, I think the following more extended statement will be found to be true and just in all its bearings.

In the year 1834 Sir James Paget, then a student, first actually determined the existence of the nematode entozoon, which was subsequently more completely described by Professor Owen. The discoverer was assisted by the celebrated botanist, Robert Brown, who lent his microscope for the purposes of examination. In the following year Professor Owen first scientifically described and named the flesh-worm (*Trichina spiralis*) in the published transactions of a learned society. He first fully interpreted the true zoological position of the parasite. Sir J. Paget's colleague, Mr. Wormald, had "more than once" previously noticed the characteristic specks "in subjects dissected at St Bartholomew's Hospital." He transmitted the individual specimens which enabled Owen to draw up his valuable paper. It is clear, however, that Mr Hilton was the first to suggest the parasitic and animal nature of the specks observed in human muscle. As the "find" was made in 1832, he anticipated Wormald in his observation of the "gritty" particles in dissecting-room subjects, describing the bodies as "probably depending upon the formation of very small Cysticerci." Nevertheless, according to Dr Hodgkin,

"the first observation of these little bodies was made in 1828" by Mr H. Peacock. The latter made a dry preparation of the *sterno-hyoideus* muscle to display the specks. That preparation is the oldest in existence, and may be seen in Guy's Museum. It may further be remarked that Henle, Küchenmeister, Davaine, myself, and others, have pointed to a notice by Tiedemann as probably, or possibly, indicating a prior observation of the specks. Leuckart rejects the evidence. Dr Pagenstecher appears to be in doubt as to the nature of the bodies in question. As the passage in question possibly gave a rough and imperfect description of the now familiarly known calcified Trichina capsules, I give a translation of it (Froriep's 'Notizen,' 1822, Bd. i, s. 64):—"At a post-mortem examination of a man who had been a great brandy-drinker, and who died from thoracic dropsy after several severe attacks of gout, Tiedemann found white stony concretions in most of the muscles, especially at the extremities. They lay in the cellular tissue between the fibre-bundles, frequently also attached to (or near) the walls of the arteries, being from two to four lines long, and roundish. The chemical examination conducted by Gmelin yielded seventy-three parts phosphate of lime, seven parts carbonate of lime and twenty parts animal matter, resembling albumen or fibrin." In regard to this notice Dr Pagenstecher ('Die Trichinen,' s. 4) has remarked that Tiedemann's "communication was also referred by Henle to such a parasitic development when he subsequently found Trichina; and in this sense it was afterwards received by Diesing, Küchenmeister, and Davaine. But it has been rejected by Leuckart on account of the size (from two to four lines) and seat of the concretions. True, it has never yet been observed that the capsuled Trichina (not measuring a tenth part of that diameter) subsequently constituted centres of gouty deposit exceeding their own bulk, nor is it likely that they should. Seeing, however, as we often do, that errors respecting size have crept into works on Trichina, we shall not need to lay much stress upon these statements; still less so since the notice is very superficial, and its character is essentially of a physiologico-chemical nature. But this, at least, seems to us decisive, that when Bischoff, at Heidelberg, wrote on a case which occurred in Heidelberg, not one single word was mentioned respecting a former case, if such should have happened, although Tiedemann and himself were on terms of close intimacy." So much for Tiedemann. In regard to

Klencke's claims, the same observer writes:—"Klencke has asserted that he had already drawn Trichinæ in the year 1829, and that he had seen them again in 1831. This subsequent statement has no kind of confirmation. The unreliableness, mistakes, and self-deceptions in the helminthological writings of Klencke have been repeatedly exposed some twenty years ago." Prior to this criticism by Pagenstecher, Professor von Siebold and several other well-known helminthologists had already commented on Klencke's assertions in the same destructive manner.

In regard to the experimentation and the valuable instruction thus acquired, it appears that Herbst was the first to rear muscle-flesh-worms, or encapsuled Trichinæ, in animals (1850); whilst Virchow was probably the first to rear and recognise sexually-mature intestinal Trichinæ in a dog ('Deutsche Klinik,' 1859, s. 430); yet, without doing injustice to others, it must be added that it remained for Prof. Leuckart to offer a full, complete, and correct solution of the principal questions relating to the source and mode of genesis of the flesh-worm (1860). Leuckart likewise did good service by disproving the erroneous views that had been put forth by Küchenmeister. Lastly, all these brilliant results culminated in the clinical observations of Zenker, who opened out a new epoch in the history of trichinal discovery. Professor Zenker was the first to detect the young in the act of migration, and he likewise primarily demonstrated the fact that the larval parasites were capable of producing a violent disease in the human body.

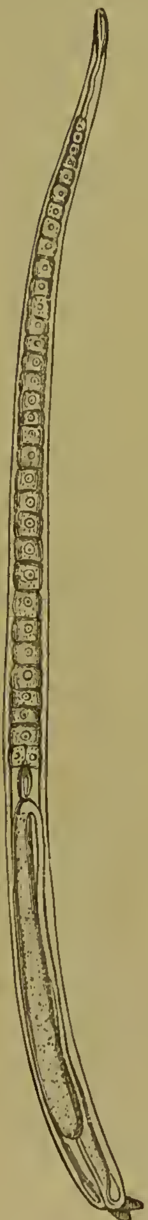

FIG. 35.—Sexually mature *Trichina spiralis*; male. After Leuckart.

Never in the history of biological science have more valuable issues followed the method of experiment upon animals. Not only has human life been thus saved, but animal life also. State-medicine and sanitation have received an immense impulse. The good that has already resulted is simply incalculable; nevertheless, in the eyes of a set of ignorant fanatics who infest this country, all experiments "involving cruelty to animals" ought to be prevented at any cost. The further progress of biological science in England has hereby sustained a severe check.

The *Trichina spiralis* in its sexually-mature state is an extremely minute nematode helminth, the adult male measuring only the $\frac{1}{18}$th of an inch, whilst the perfectly developed female reaches a length of about $\frac{1}{8}''$. The body is rounded and filiform, usually slightly bent upon itself, and rather thicker behind than in front, especially in the males. The head is narrow, finely pointed, unarmed, with a simple, central, minute oral aperture. The posterior extremity of the male is furnished with a bilobed caudal appendage, its cloacal or anal aperture being situated between these divergent appendages. The penis consists of a single spicule, cleft above, so as to assume a V-shaped outline. The female is stouter than the male, bluntly rounded posteriorly, having the genital outlet placed far forward, at about the end of the first fifth of the long diameter of the body. The eggs measure $\frac{1}{1270}''$ from pole to pole. The mode of reproduction is viviparous.

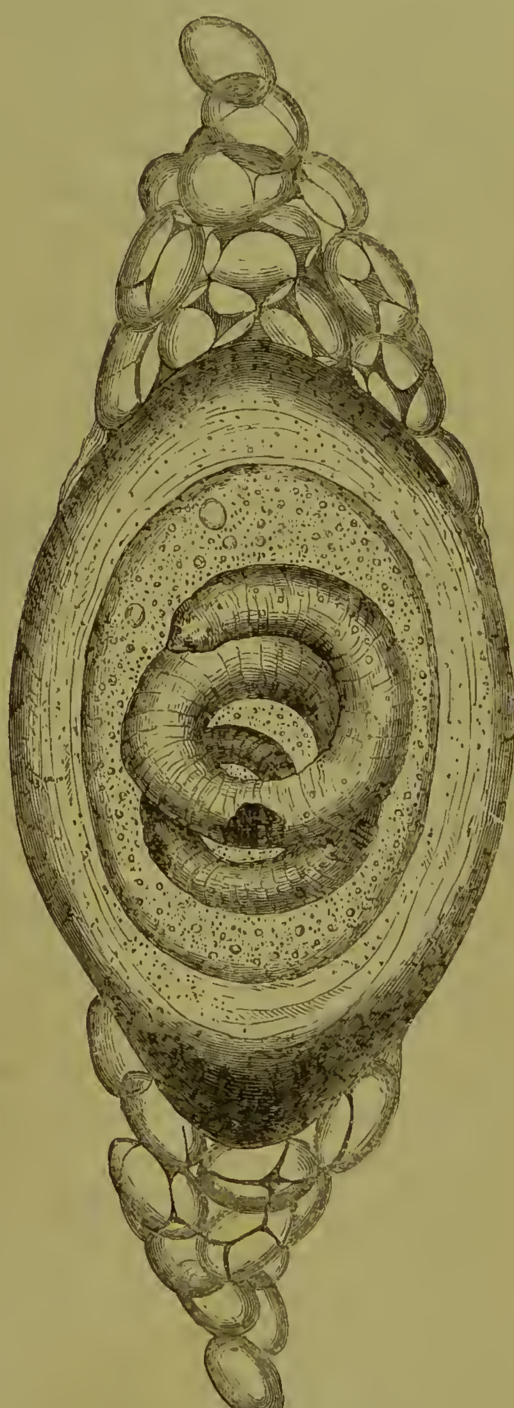

FIG. 36.—Larval Trichina coiled within its capsule. After Bristowe and Rainey.

As commonly observed in the human body our young Trichinæ appear as spirally-coiled worms in the interior of small, globular, oval, or lemon-shaped cysts, which latter appear as minute specks scarcely visible to the naked eye. These specks resemble little particles of lime, being more or less calcareous according to the degree of degeneration which their walls have undergone. In shape and general aspect they are not altogether unlike the eggs of certain nematoid worms, but their size alone sufficiently distinguishes them. They measure on an average $\frac{1}{78}''$ in length by $\frac{1}{130}''$ in breadth.

The organised capsules are not essential to the further development of the parasite, and are rather to be regarded as abnormal formations, or rather, perhaps, as products resulting from an effort of nature to protect and thus prolong the life of the occupant. They are frequently altogether wanting. The capsuled Trichinæ measure $\frac{1}{25}''$ in length by about $\frac{1}{630}''$ in breadth. When fully formed they not only exhibit a well-marked digestive apparatus, but also reproductive organs, which are often, indeed, sufficiently developed to determine the sex.

Notwithstanding the large number of experiments that have been more or less recently made by investigators, little or nothing has been discovered calculated to disturb the conclusions set forth by Leuckart, who writes as follows :—" (1) *Trichina spiralis* is the juvenile state of a little round worm, previously unknown, to which the generic title of Trichina must remain attached. (2) The sexually mature Trichina inhabits the intestinal canal of numerous warm-blooded animals, especially mammalia (also of man), and constantly in great numbers. The duration of its life extends from four to five weeks. (3) At the second day after their introduction the intestinal Trichinæ attain their full sexual maturity. (4) The eggs of the female Trichinæ are developed within the uterus of the mother, into minute filaria-like embryos, which, from the sixth day, are born without their egg-shells. The number of young in each mother-worm is at least from ten to fifteen thousand. (5) The new-born young soon after commence their wandering. They penetrate the walls of the intestine and pass directly through the abdominal cavity into the muscles of their bearers, where, if the conditions are otherwise favorable, they are developed into the form hitherto known. (6) The directions in which they proceed are in the course of the intermuscular connective tissues. (7) Only the striped muscle (that of the heart excepted) contains Trichinæ. The majority of the wandering embryos remain in those sheathed muscular groups which are nearest to the cavity of the body, especially in those which are smaller and most supplied with connective tissue. Speaking generally, their number decreases with the distance from the abdomen, being, however, more numerous in the anterior half of the body. (8) The embryos penetrate into the interior of the separate muscular bundles, and here already, after fourteen days, acquire the size and organisation of the well-known *Trichina spiralis.* (9) Soon after the in-

trusion of the parasite the infested muscular fibre loses its original structure, the fibrillæ collapse into a finely granular substance, whilst the muscular corpuscles change into oval nucleated cells. (10) The infected muscular bundle retains its original sheathing up to the time of the complete development of the young Trichinæ, but afterwards its sarcolemma thickens, and begins to shrivel at the extremities. 11. The spot inhabited by the rolled-up parasites is converted into a spindle-shaped widening, and within this space, under the thickened sarcolemma, the formation of the well-known lemon-shaped or globular cysts commences by a peripheric hardening and calcification. This degeneration commences several months after the wandering. Immature muscle-Trichinæ are not capable of producing infection. (12) The migration and development of the embryos also take place after the transportation of impregnated Trichinæ into the intestines of a new host. (13) The further development of the muscle-Trichinæ into adult animals is altogether independent of the formation of the calcareous shell, and occurs as soon as the former have reached their completion. (14) Males and females are already recognisable in their larval state. (15) The immigration of the Trichina-brood in masses produces very grave or even fatal consequences, such as peritonitis (from the embryos perforating the intestinal walls), pain, and paralysis (resulting from the destructionof the infected muscular fibres). (16) The infection of man occurs especially through swine. (17) The muscle-Trichinæ are so capable of resistance that they are by no means in all cases destroyed by the ordinary methods of roasting, cooking, pickling and smoking. (18) As a rule, swine obtain Trichinæ from rats, to which latter we also as the natural bearers have to convey them. Microscopic examination of

FIG. 37.—Immature female Trichina from muscle. After Leuckart.

flesh is, therefore, urgently recommended as a public preventive against all danger from Trichinæ."

As a summary the above conclusions are well nigh exhaustive; but whilst I purposely avoid entering into mere clinical details, there are points of hygienic interest to which I must allude. Thus, as regards the number of larval Trichinæ in any one "bearer" at a time, this, of course, must be extremely variable, but it may amount to many millions. In one of the cats on which Leuckart experimented, he estimated a single ounce of its muscle-flesh to harbour no less than 325,000 Trichinæ. I find that a relatively similar degree of infection in an ordinary human "bearer" would yield thirty millions. In the case of one of my own experimental animals, a pig, I reckoned that there were at least sixteen millions of Trichinæ. The larvæ were about ten months old and enclosed within perfectly formed capsules; nevertheless, the animal had never displayed any symptom of irritation. In a trichinised human subject, examined by Dr Thudichum, it was estimated that 40,000,000 parasites were present. My own estimate, calculated from specimens of muscle obtained from the same case, gave 100,000,000 as the approximate number of worms present. In the only outbreak of Trichinosis occurring in England, details of which will be given further on, I found that the flesh of the hog that had caused the local endemic contained upwards of 80,000 Trichinæ to the ounce. The consumption of a pound of such flesh would be capable of producing a collective progeny of something like 400,000,000 within the human "bearer."

In the year 1865 I conducted a series of experiments upon upwards of a score of animals, including seven birds, the latter all yielding only negative results. So far as muscle-Trichinæ were concerned my experiences accorded with those of Professors H. A. Pagenstecher and C. J. Fuchs, at the Zoological Institute in Heidelberg. These experimenters found that the ingested muscle-Trichinæ acquired sexual maturity within the intestinal canal of their avian "hosts;" but they never found young Trichinæ in the muscles of the birds, nor did they perceive any evidences of an attempt on the part of the escaped embryos to effect a wandering or active migration on their own account. Clearly, if the bird's intestinal canal were a proper territory for the residence of sexually mature Trichinæ, we should have found abundance of wandering non-encapsuled flesh-worms and also sexually-immature muscle-Trichinæ enclosed in well-formed

capsules. Not a few persons still entertain the notion that Trichinæ are liable to infest all kinds of warm-blooded, and even also many kinds of cold-blooded animals, such as reptiles and fishes. Certain nematodes found in earth-worms have been described as Trichinæ; and consquently, pigs and hedgehogs were said to become trichinous through eating these annelids. The minute flesh-worms described by Bowman from the muscle of the eel are not true Trichinæ, any more than the somewhat similar parasites which Eberth found to infest the muscles of the frog. The same may also be said of Dr Salisbury's urinary Trichinæ, which are the larvæ of *Filaria Bancrofti.*

Deducting the seven birds, and also six other animals where no examination after death was possible, I ascertained the result of my worm-feedings in sixteen instances. Nine of the experiments were entirely successful, the infected animals comprising four dogs, two cats, one pig, one guinea-pig, and a hedgehog.

Carnivorous mammals, especially those subsisting on a mixed diet, are the most liable to entertain Trichinæ, but it is quite possible to rear them in herbivora. Thus, Pagenstecher and Fuchs succeeded in rearing muscle-Trichinæ in a calf, and they found three female intestinal Trichinæ in a goat, but apparently no muscle-flesh-worms, althougth twenty-seven days had elapsed since the first feeding with trichinised rabbit's flesh. In three sheep on which I experimented no trace of Trichinæ could be found. There is no practical need for any further experiments on herbivora, for it is quite clear that, in their natural state, herbivorous mammals can seldom have an opportunity of infesting themselves, whilst the reverse is the case with swine, carnivorous mammals, and ourselves. Because many quadrupeds become trichinous, it does not follow that all mammals are liable to be infested. In the case of most parasites we find the species limited to a larger or smaller number of hosts. On the other hand, in not a few cases, the range of the entozoon is limited to a single territory or host.

In conducting the experiments above mentioned I was assisted by Professors Simonds and Pritchard, of the Royal Veterinary College. As they were the only researches conducted on any considerable scale in England, I subjoin a few details of them. Dr Thudichum's experiments were, I believe, confined to rabbits.

Exps. 1 and 2.—On the 15th of March, 1865, an ounce of

flesh containing Trichinæ was administered by myself to a black bitch. The dog being destroyed five days subsequently, neither intestinal nor muscle-Trichinæ were discovered. It was thought that the dog had thrown up the bolus, which was strongly saturated with chloride-of-zinc solution. The bolus consisted of a portion of the *pectoralis major* of a subject brought to the dissecting-room at the Middlesex Hospital. The cysts were highly calcified, but the majority contained living embryos, which were quite unaffected by the zinc solution injected into the body to prevent decomposition. At the same date a small white puppy was experimented on and examined with precisely the same results. In either case it was too early to expect muscle-flesh-worms to have become developed.

Exp. 3.—Half an ounce of the same trichinous human flesh was given (at the same date) to a black-and-tan puppy reared at the Royal Veterinary College, a second "feeding" being administered on the 21st of March, or six days after the first. In this case Mr Pritchard, who fed the animal, took the precaution to chop the muscle into small pieces, and to mix it with other food, in order that the flesh might be the more readily retained in the stomach. The puppy was not destroyed until the 15th of the following June, when, on examination, numerous encysted but non-calcified muscle-Trichinæ were found in all the voluntary muscles subjected to microscopic scrutiny.

Exp. 4.—An ounce of the same flesh was given to a dark-colored pig on the 15th of March, and again on the 20th, several other "feedings" being also administered during the month of April, 1865. It was destroyed on the 16th of May, but no Trichinæ were detected.

Exp. 5.—An ounce of the same human muscle-flesh administered to a small sheep (which was subsequently killed on the 29th of June) also produced negative results.

Exps. 6 and 7.—"Feedings" were at the same time administered to a rat and mouse. The mouse died on the 2nd April, when I examined its muscles without success. On the following day the rat unfortunately made its escape, but whether trichinised or not cannot be said.

Exp. 8.—An ounce of trichinous human flesh was given to a donkey, in the form of "balls," on the 20th of March; and during the month of June four other separate "feedings" with trichinous dog's flesh were also administered. The animal was removed from the College without the result being ascertained.

Exp. 9.—From the 15th to the 20th March, 1865, inclusive, three small Trichina "feedings" were likewise administered to a guinea-pig. This little animal was not destroyed until the 15th of the following June, when a positive result was obtained. The *pectoralis transversus* and other muscles were found to harbour a considerable number of encysted Trichinæ.

Exp. 10.—On the 20th March, and again on the 21st (1865), "feedings" from the same human subject were administered to a hedgehog. On the 26th of April the animal seemed to be attacked with symptoms of Trichinosis. It refused food, kept its head extended, and the eyelids closed. On the 27th it appeared much worse, and on the morning of the 28th it was found dead. On the 29th I examined the flesh, and found abundance of living Trichinæ in the muscles. The capsules were very thin and transparent. A few days later Mr Simonds also examined the flesh, and confirmed this result.

Exps. 11 and 12.—Two chickens were fed, on the 21st of March, with the same material. One of the birds died on the 24th, when I examined the intestines and detected one or two very minute nematodes, which, at the time, I believed to be imperfectly developed Trichinæ, but subsequently saw reason to alter my opinion. The other bird died on the 3rd of April, and certainly contained no muscle-Trichinæ.

Exp. 13.—On the 22nd and 23rd of March "feedings," amounting to an ounce of flesh in all, were given to a mole. This animal was returned to the care of Mr Charles Land, who had previously sent it to the Veterinary College. He subsequently reported that, after observing the mole to be "working" for two or three days, he lost all trace of it, and concluded that it had either escaped or was dead.

Exp. 14.—On the 1st and 2nd of May portions of the left fore extremity of the hedgehog (in which we had successfully reared Trichina from the Middlesex-Hospital subject) were offered by Mr Simonds to a cat. It ate the flesh very readily, consuming the entire limb. On the 15th of the following June the cat was killed, when living Trichinæ were found within all the muscles which we examined.

Exp. 15.—At the same dates a young terrier dog was similarly treated, but did not take the "feeding" so readily. In this case the left hind extremity of the hedgehog was employed, and what was not eaten voluntarily was forcibly introduced. On the 1st of June the dog was attacked with "distemper," and

died on the 8th of the same month. On examination we found several living Trichinæ in the *sterno-maxillaris* and other muscles. Some of the parasites were encysted.

Exp. 16.—From the 9th to the 12th of June inclusive four separate worm-feedings with the flesh of the trichinised terrier-dog were administered to a crow. The bird was killed some months afterwards and sent to me for examination. Its muscles were entirely free from Trichinæ.

Exp. 17.—From the 9th to the 17th of June inclusive seven separate worm-feedings were administered to a pig. One of the "feedings" was with the trichinised guinea-pig's flesh, the others from the dog. This animal was not destroyed until the 4th of April, 1866, when all the muscles which I examined were found extensively infested with Trichinæ. There were probably not less than 16,000,000 present, all being alive and enclosed within perfectly-formed capsules, none of which latter exhibited any traces of calcareous deposition.

Exp. 18.—Four separate feedings with trichinous dog's flesh were likewise, at the same dates as the foregoing, administered to a rat. This experimental animal, however, like the one previously mentioned, contrived to make its escape. I fear it was well trichinised.

Exp. 19.—About the same date trichinous "feedings" were given to a black puppy (bred at the Veterinary College). The dog was killed on the 18th of August, 1866, having also been made the subject of an echinococcus-feeding, when I found abundance of encysted Trichinæ within the voluntary muscles.

Exp. 20.—Four separate worm-feedings with the flesh of the trichinised guinea-pig were given to a sheep on the 15th, 16th, 17th, and 19th days of June, 1865. The experimental animal was destroyed on the 29th of the same month, but the result was negative.

Exps. 21 and 22.—"Feedings" with the guinea-pig's flesh—four in the one case and three in the other—were also administered by Mr Simonds (from the 15th to the 19th of June, inclusive) to a chicken and goose respectively. These birds were destroyed some months afterwards and sent to me for examination, but the most careful scrutiny failed to detect any Trichinæ within their muscles. The goose was cooked and eaten without the slightest hesitation. The chicken I found too tough for consumption.

Exp. 23.—On the 28th of March, 1866, I obtained a small

quantity of muscle from a highly trichinised German subject, who died from the effects of an accident at the London Hospital the day previous. The case was fully reported by Dr Thudichum in a new journal, called 'Scientific Opinion' (No. 4, April 25th 1866, p. 55). During the same day (at 2.30 p.m.) I fed a dog with part of this human flesh. On the morning of the 31st I killed the dog, and examined the intestinal canal (at 11.30 a.m.), which revealed the presence of sexually-mature living Trichinæ. The males (of one of which I retain an accurate figure) displayed the characteristic bilobed caudal appendage, leaving no doubt as to their source and nature. I have mentioned the precise time of the experiment, in order to show that a period of sixty-nine hours proved amply sufficient for the development of the young muscle-flesh-worms of the human subject into the sexually-mature adult Trichinæ of the dog.

Exp. 24.—With another portion of this human flesh (taken from the muscles of the tongue) in which the Trichinæ were extraordinarily abundant, I fed a cat. In about ten days the animal showed the most marked symptoms of trichinosis. It refused to eat; the eye lost its lustre; the body became very thin, and I thought the animal would die. By very great care, keeping it warm before the fire, and subsequently inducing it to take a little milk, the creature improved, gained flesh, and eventually recovered. About three months afterwards I destroyed this cat, when on examining the *panniculus carnosus, latissimus dorsi,* and other superficial muscles, I found great quantities of well-developed, capsuled Trichinæ. Although the animal had swallowed scarcely a quarter of an ounce by weight of the infested flesh, yet thousands of parasites had been propagated and dispersed throughout its muscular system. In this way the helminthiasis nearly proved fatal to my cat. As has been already stated, Dr Thudichum, who I believe had an opportunity of examining the corpse of this trichinised German, estimated the number of parasites in his body at 40,000,000. I do not think this estimate likely to be exaggerated, for if all the flesh had been infested to the extent I found to obtain in respect of the muscles of the tongue, I believe 100,000,000 would have been nearer the mark. In places the point of a needle could scarcely be thrust between the capsules, so closely were they agglomerated.

Exp. 25.—From the 19th to the 25th of April, 1866, inclusive,

daily administrations of trichinous pork, in the form of bolus, were made to a sheep by Mr Pritchard. The Trichinæ were obtained from one of our experimental animals at the Veterinary College, about two ounces of the flesh being given at each feeding. The flesh of this sheep (destroyed in the following November) failed to give any indication of the presence of parasites.

Exps. 26 and 27.—About the same time, and occasionally at intervals extending over a period of five weeks, Mr Pritchard also fed two young fowls with the same trichinous pork. Towards the close of October, 1866, both birds died, when Mr Pritchard carefully examined the flesh of them, but failed to find any trace of Trichinæ.

Exps. 28 and 29.—From April 2nd to the 9th of the same month, 1866, inclusive, feedings with trichinous pork were likewise given to two dogs. These animals were destroyed and examined by Mr Pritchard in November, 1866, but the result appears to have been negative.

It is perfectly certain that the infection of man by Trichina is invariably due to the ingestion of verminiferously diseased meat, and as remarked in my 'Lectures,' whenever the parasites are taken in large numbers unpleasant symptoms soon show themselves in the infested person. There is, first of all, restlessness, loss of appetite, and more or less prostration. This is succeeded by rheumatoid pains in the limbs, with the frequent accompaniment of considerable swelling. The pain is not situated in the joints, but in the intermediate soft parts. In severe cases the limbs are drawn up and half bent, as in instances of severe and continued cramp. Sometimes the suffering is excruciating and unbearable, patients having been known to request the surgeon to put an end to their lives. In the worst forms of the malady death rapidly ensues from diarrhœa and exhaustion. If the parasites have gained admission to the muscles all hope of destroying them is at an end; but if a person suspects himself to have eaten diseased or trichinised meat he should lose no time in seeking professional assistance, seeing that the administration of suitable anthelmintics might be the means of saving his life, whereas a few days' delay would probably prove fatal. So long as the worms remain in the stomach or intestinal canal they can be got rid of, but when once the trichinal brood have invaded the flesh then they cannot be expelled. As remarked in my 'Entozoa,'

it is easy to perceive that although, in the majority of instances, Trichiniasis does not cause death, yet the percentage of fatal cases is by no means insignificant.

The notion that particular breeds of swine are more liable to be infested than others is absurd, since infection must be due to the facilities offered for swallowing garbage, especially dead rats. According to Drs Belfield and Atwood 8 per cent. of slaughtered American swine contain Trichinæ. In infested hogs they found from 35 to 13,000 parasites in a cubic inch of muscle, and by repeated feedings they succeeded in rearing about 100,000 Trichinæ in the body of a rat.

In regard to the disease in man let us glance at the phenomena that presented themselves in Plauen, a town of Central Saxony. Drs Böhler and Königsdörffer, who first saw this disease and treated it, state, according to Leuckart, that "the affection began with a sense of prostration, attended with extreme painfulness of the limbs, and, after these symptoms had lasted several days, an enormous swelling of the face very suddenly supervened. The pain occasioned by this swelling and the fever troubled the patients night and day. In serious cases the patients could not voluntarily extend their limbs, nor at any time without pain. They lay mostly with their arms and legs half bent—heavily, as it were, and almost motionless, like a log. Afterwards, in the more serious cases, during the second and third week, an extremely painful and general swelling of the body took place; yet, although the fifth part of all the patients were numbered amongst the serious cases, only one died."

Satisfactory as it may be to note the numerous recoveries which take place, this circumstance is very much marred by the fact that a large proportion of the patients suffer the most excruciating agony. In the main it will be observed that Böhler's and Königsdörffer's experience, as recorded by Leuckart, corresponds very closely with that given by other observers. The symptoms, moreover, are very similar to those produced in the original case published by Zenker. In this case, which occurred in the Dresden Hospital (1860), the patient was a servant girl, aged twenty, and the principal symptoms were loss of appetite, prostration, violent pains, contraction of the limbs, and finally œdema, which, in association, perhaps, with a certain amount of pneumonia, terminated her career within a period of thirty days. The post-mortem appearances showed

that the larval Trichinæ were the cause of death. The intestinal canal contained numerous sexually-mature worms.

The effects produced by Trichinæ on animals are similar to those occasioned in man. The phenomena were summarised by Davaine (in the journals quoted below) in 1863 as follows:

"The first phase is characterised by intestinal disorder, produced by the development of the larvæ in large numbers, and their adhesion to the mucous membrane of the intestine. In this stage M. Davaine has seen rabbits die with intense diarrhœa; one of two cats which he fed with trichinised meat had diarrhœa for at least a fortnight, but survived. Of five or six rats fed on a similar diet, one only, which was pregnant, died of diarrhœa, after abortion, on the eighth day. According to M. Leuckart, the passage of the embryos of Trichinæ through the intestinal walls sometimes produces peritonitis. This intestinal phase often becomes blended with the next; it may be relieved by the expulsion of the worms by means of the diarrhœa, or may cease with the natural death of the worms.

"The second stage presents general symptoms—muscular pains, &c. These phenomena are dependent on the introduction of the Trichinæ into the muscles; they rapidly acquire their maximum intensity, and have not a long duration. The appearance and duration of this stage are in complete relation with the development and length of sojourn of the Trichinæ in the intestines; in fact, in this entozoon, oviposition is not slow and of long duration, as in many nematoid worms; the genital tube is rapidly formed, and the ova, in its whole length, are developed almost simultaneously, so that the embryos, arriving soon at maturity, are at once thrown out in large numbers into the intestine, and the mother Trichina dies exhausted. If it be remembered that the embryos do not escape before the eighth day, that a certain number of days are required for their arrival in the muscles, and that new ones are not produced after six or seven weeks, it will be understood that the first symptoms of this stage can scarcely appear until the end of a fortnight after ingestion of the diseased food, that they must continue four or five weeks, and that after this they may disappear. This course of events is observed in animals; and in man the symptoms of this stage have shown themselves and become aggravated from the third to the sixth week after infection. Most animals die during this stage; rabbits rarely survive; rats, on the contrary, generally resist it.

"If the animals do not die of the general symptoms or local disturbances proper to these two stages, the inflammatory symptoms cease, respiration becomes natural, and order is re-established. But, in some cases, the number of cysts formed in the muscles are sufficiently great to impede them in the proper exercise of their functions, and hence arises general debility, a kind of consumption which persists or becomes aggravated, and the animal dies of marasmus. M. Davaine has noticed this in rabbits, but especially in a rat.

"Recovery from these phases of trichinal infection may be apparently perfect. A rabbit which M. Davaine kept during five months became large and fat, although it had a large number of Trichinæ in its muscles; a rat which had had these entozoa in considerable numbers during six months was, to all appearance, in good health. Hence he concludes that the Trichinæ produce symptoms only when they are in the intestinal canal, and when they are entering the muscles. Having become lodged in their cysts among the muscular fibres, they may remain harmless for an indefinite time. In every case except one, down to 1859, Trichinæ have been found in the bodies of persons who have died of disease (generally chronic) or by accident; or in the dissecting-room, in bodies regarding which the previous history could not be obtained. In most cases the cysts contained a cretaceous or fatty deposit, showing that they had probably existed several years.

"The observations which have been made on the human subject, in regard to the symptoms caused by Trichinæ, show that they belong, as in animals, to the initial period of infection. They consist in intestinal and in muscular lesions; the latter coincide with the entrance of the parasite into the muscles, and are truly traumatic. In Zenker's case the intestinal symptoms were swelling and pain; in a case described by Friedreich diarrhœa was present. In all cases the most remarkable symptoms were violent rheumatoid pains in the muscles, not in the joints, which were considerably aggravated by attempts to extend the half-bent limbs. The other symptoms have been variable, but have had a strong resemblance to those of typhoid fever. In several cases there has been abundant sweating; and in one there was a very remarkable miliary and furuncular eruption. The animal heat was diminished in Friedreich's case; and in those observed in Voigtland by Freytag the temperature never exceeded 102° Fahr.

"The progress, duration, and severity of the disease in man are in relation to the number of Trichinæ taken into the digestive canal. Of sixteen patients observed at Plauen by Drs Böhler and Königsdörffer, eight, who were moderately affected, recovered in a month; four, more severely diseased, were ill two months; of four others, one died with ascites and colliquative diarrhœa at the end of two months, and three recovered slowly at the end of three or four months. Recovery does not imply the death of the Trichinæ, it follows their enclosure in cysts.

"The diagnosis of trichinal infection has several times been made in the living human subject by removing a portion of muscle. M. Davaine thinks it probable that, during the first six or eight weeks of the disease, the diagnosis may be confirmed by searching for adult Trichinæ in the alvine evacuations, produced naturally or by means of a purgative.

"The prophylactic treatment consists simply in the avoidance of uncooked meat. The medicinal treatment must vary with the stage of the disease. At first, attempts must be made to expel the parasites from the intestines by purgatives and anthelmintics. Which amongst the latter is the most energetic is not yet determined. Calomel is, perhaps, M. Davaine thinks, the best. After six or eight weeks all treatment directed towards the intestines is superfluous. It is scarcely probable that any substance will act on the larvæ disseminated through the muscles. Friedreich has recommended picronitrate of potash; but, in the case in which he used it, live Trichinæ were found in the muscular tissue after the patient was considered to be cured."

In regard to the possibility of curing trichiniasis by the administration of drugs which should act as trichinacides upon the parasites in the condition of flesh-worms, the absurdity of the proposal only equals that which was made in reference to the destruction of hydatids by the administration of kamala. As has been shown in the record of my first experiment the flesh of a trichinised corpse may be thoroughly saturated with a strong solution of chloride of zinc, and yet the worms will remain quite unaffected.

In reference to the dangers arising from the consumption of diseased meat, Professor Gamgee has very cogently put two questions :—"Did Moses know more about pigs than we do ?" "Was it a knowledge of the parasitic diseases of swine and man

that led Moses to condemn pork as human food?" Mr Gamgee answered both questions negatively, thus:—"The wisdom of the Mosaic law can only be justly estimated with a knowledge of the accidents arising in warm countries from eating pork throughout long and hot periods of the year; and there is no doubt that the direct evil results, as manifested by human sickness, led to the exclusion of pork from the list of Israelitish viands. The masses of measly pork which may be seen hanging from the butchers' stalls in Southern Europe prove that the long-legged swine which hunt the forests for acorns, and rove about to pick up all kinds of offal, are often unfit for human food, and that they were so to no less extent in the land of Israel is probable." As supplementing Professor Gamgee's argument, I may remark that, if Moses had been furnished with special knowledge beyond that of his contemporaries, he would not, in the matter of meat-parasitism, have confined his restrictions to pork. Had he possessed any knowledge of measly beef, he would not have spared the ox on the ground that although "it divideth the hoof, yet it cheweth the cud." As regards home-reared animals, Professor Gamgee cogently remarked: "It is interesting to observe that parasitic maladies in the pig specially abound in that section of the United Kingdom where swine live most amongst human beings. The Yorkshire and Berkshire pigs, in their native counties enclosed in the farmyards of their breeders, are free from worms which are likely to live in the body of man. The Irish pig is the one most commonly injured by entozoa, and the reason for this is evident when we know how much the cottager relies on rearing a porker which is permitted the free range of house and road, where every description of filth is devoured, charged with the ova of parasites expelled by man or some of the lower animals." He also adds: "The conditions under which we live in the British isles are certainly much less favorable to the propagation of worms; but we disregard, in our ignorance, the most common precautions to protect ourselves from loathsome diseases, and not only permit dogs to eat any kind of offal in and around slaughterhouses, but sanction the existence of piggeries where all kinds of garbage, charged with worms or their eggs, are daily devoured by swine. The majority of germs calculated to engender parasites are to be found in abundance in the contents of the alimentary canal of human beings and domestic quadrupeds. If pigs are permitted to eat

these, as in Ireland or in many British piggeries, we must expect hams, bacon, and pork sausages to be charged with the embryonic forms of human entozoa. Whereas in Iceland the *dog* is the victim of human negligence, and *en revanche* the cause of human disease, in the British isles the *pig* holds this unenviable position. We have good reason to believe, with Moses, that the pig is an unclean beast; but without discarding him from the scanty list of animals to be eaten, it is evident that we can purify the race of swine, and thus prevent human as well as porcine maladies."

On the authority of Rupprecht, as quoted by Davaine, I append a list of the principal epidemics observed in Germany during the first six years immediately following the discovery of trichinosis:

1. Two slight epidemics in 1860 in the Island of Rügen; 10 to 20 patients (Dr Landois).
2. An epidemic at Stolberg, 1860 (Dr Fricinus). The number of trichinised persons was not stated with certainty.
3. Five epidemics during five summers, 1858 to 1862, at Magdebourg. The number of patients was 300, two only died (Dr Sendler).
4. An epidemic at Plauen in 1862, 20 patients (Böhler).
5. Gusten, 1861, 40 cases, all cured (Fränkel).
6. Epidemic in the Province of Armsted (Mansfeld), 1861, 8 patients.
7. Hettstädt, January and March, 1862, 8 to 10 patients.
8. Blankenburg, 1862, 278 cases, 2 deaths.
9. Calbe (Prussia), 1862, 38 cases (9 men, 25 women, 4 children), 8 deaths (Dr Simon and Dr Herbst).
10. Burg, in Magdebourg, 1863, 50 patients, 10 deaths (Dr Klusemann).
11. Quedlinburg, 1863, 9 patients, 1 death (Dr Behrens).
12. Plauen, 1863, 21 patients (Königsdörffer).
13. Falkenstein, 1863, 4 patients (Drs Bascher and Pinter).
14. Posen, August and September, 1863, 37 patients (Dr Samter).
15. Hamburg, 1863, 2 patients (Dr Tüngel).
16. Blankenburg, 1863, 32 patients, 2 deaths; new cases in 1864 (Dr Scholz).
17. Hettstädt (Prussian-Saxony), October, 1863, 158 patients, 27 deaths (Rupprecht).
18. Eisleben, December, 1863, and January, 1864, 18 cases,

no deaths. This result was attributed to the employment of phosphoric acid (Rupprecht).

19. Hettstädt, February and March, 1864, 8 patients, no deaths. Two cats were also attacked, one of which died. Nearly 50,000 Trichina were counted in an infected leg of pork (Rupprecht).

20. Quedlinburg, 1864, 120 patients, 2 deaths; benzine was employed (Dr. Wolf).

21. Hettstädt, January, 1865, 15 patients (Rupprecht).

22. Berlin, 1864, 3 cases (Dr Cronfeld). Several butcher boys (Frischer).

23. Leipzig, 1864, 14 patients, 2 deaths; 4 were infested after having eaten raw beef hashed on a block which had previously received the flesh of a trichinised hog (Dr E. Wagner).

24. Potsdam, 1864, 5 slight cases (Dr Mollendorf).

25. Celle (Hanover), 1864, 8 patients (Dr Scheller and Dr Baring); Trichina proven in the pork by Gerlach. In 1855, 12 Trichina (?) patients were treated by Schuchart.

26. Hedersleben, 25th October, 1865, a pig was killed and sold; on the 28th the malady appeared amongst the workmen; 350 patients, 100 deaths. Of 100 children infected, none died. Trichina found in the autopsies (Dr F. Kratz).

Dr Davaine also adds the following outbreaks:

In Massachusetts, 1867, 6 patients from having eaten raw ham, 1 death ('Medical Times,' 20th April, 1867, p. 431).

Ravecchia (Bellinzona), 1868, 5 patients, 4 deaths (Dr Zangger (in *Landbote* of Winterthur).

Up to a comparatively recent date no case of trichinosis had been recognised in England during the life of the victim. As regards diagnosis, what was happening every day on the Continent was utterly unknown here. Whilst, however, not a single instance of Trichina-disease had been observed by British physicians in actual practice, as many as thirty or forty instances had occurred where the parasites in question had been found post mortem. I had myself examined the trichinised flesh taken from a dozen of these corpses, but in no instance had the faintest suspicion of trichinosis been entertained during life. The circumstances attending the only outbreak of trichiniasis that has been witnessed in England are very interesting. In the month of April, 1871, I received from Dr W. L. Dickinson, of Workington, Cumberland, specimens of pork which he requested me to examine; and in complying with

his request I confirmed his opinion that the diseased meat was infested with Trichinæ. A few days afterwards I announced the discovery in the pages of the 'British Medical Journal' for April 22, p. 435. It happened, also, that at the time I was delivering a course of lectures before the Society of Arts; consequently, in my second discourse (which was devoted to the parasites of cattle) I gave full details of the facts that were obtained. Taking a small portion of the flesh which I judged to be affected to an average extent I addressed the audience as follows:

"If you calculate from one portion only, you might, if you had stumbled upon a part which was more infested with parasites than another, be led to over-estimate the degree of trichinisation. Taking proper precautions I have calculated that one scruple of this trichinous flesh would give us 4320 parasites, and two scruples would therefore yield 8640. Without speaking so precisely to numbers, I do not hesitate to aver my belief that there are at least 5000 of these parasites inside this small piece of ham. The number is probably close upon 8640. In one drachm that would give us 12,000, and in an ounce 103,000, according to the old apothecaries' weight. If, however, we calculate according to the ordinary weight used by butchers, we should say that one ounce contains 437½ grains of meat, and therefore the number of parasites in one ounce would be 85,000. Thus, in one ounce of meat from this particular pig you have 85,000 Trichinæ, calculated at the rate of 200 in the grain, for I have purposely cut off the odd numbers. You may say, if a person can survive 18, 20, 30, or 40 millions, he would not take much harm from eating a piece of flesh containing only 8640 parasites. Such a portion, however, would be quite sufficient to make any one of us extremely uncomfortable were we to eat it, for supposing its contained parasites to be alive, it might prove dangerous to life. Why? The explanation is this:—Half of those 85,000 parasites, at the very least, will, in forty-eight hours after ingestion, have become fully-developed females; and from each of these 42,000 there will proceed at least 1000 as a brood, so that the entire progeny (and it is they that do the mischief by their independent migrations through our tissues) will eventually yield about 42,000,000 entozoa. If we should be so voracious as to eat a pound of such trichinised flesh, then there would be 400,000,000 as the result of a single meal.

"Having detailed these facts and inferences, I now wish to bring to your notice some other particulars connected with the Cumberland outbreak.

"Dr Dickinson, of Workington, tells me that he was at first suspicious that his patients were suffering from fever, but was not quite able to make out what the disorder was. At length certain symptoms occurred, which suggested that it might possibly be the German flesh-worm epidemic making its appearance in this country for the first time, and, therefore, in view of verifying the facts of the case, he sent me portions of the flesh of the pig. He describes the symptoms, which in their character corresponded with those previously recorded as experienced by persons similarly attacked. Dr Dickinson remarks, towards the close of his communication, that the victims form a small family who have carefully reared their own swine. The British farmer is thus here introduced to us at his own table playing the part of 'host'—at her own table, I should say, for, to be more precise, it is a widow, her daughter, and a man-servant who are suffering. Dr Dickinson informs me that for two or three weeks before he was called to see them they had been eating sausages and boiled pork from one of their own home-fed pigs, which pig, by the way, turns out to have been an old sow. He brought away some sections of the leaner portions of the flesh for microscopic examination. You will observe that there can be no mistake about the source of the food on this occasion. Hitherto, Trichina has not been observed in our British-fed swine in more than one or two, or possibly three instances. Therefore it would be very interesting to ascertain how it happened that this poor pig became trichinised. In my communication addressed to the 'British Medical Journal,' I wrote as follows :—"Dr Dickinson has at the present time under his care a family suffering from the so-called flesh-worm disease, resulting from the consumption of ham prepared from pigs reared by the family themselves. A portion of ham sent to me swarmed with recently encapsuled Trichinæ. Dr Dickinson being thus the first person who has diagnosed trichiniasis in the living subject in England, I hope he may be induced to give us further particulars.' The editor, in commenting upon this letter, added a practical point, which I wish especially to bring to your notice. He says :—'The subject of parasitic diseases of domestic animals is one of widespread and increasing interest.

It is immediately related to the irrigation of fields with sewage.' The editor, of course, made this statement on independent grounds, and on his own responsibility. If he had said the subject bears an indirect relation to the sewage question, he would have said no more than is absolutely true, for, as I shall take occasion to explain, there is every reason to suppose that certain forms of parasitic disease may be propagated by means of sewage. In this connection some of you may be disposed to ask the question :—'Are there any sources of comfort to be gathered from the facts?' Or you may say, supposing that in future our British swine are not as free from Trichinæ as they have been hitherto, can we possibly avoid the contingency of playing the part of host to those creatures? Certainly, I reply, it is simply a question of properly cooking the food. If these farmers have not cooked their food at all, or scarcely at all, that will at once account for their being laid up. I should tell you that the lady and the daughter are recovering, and that they are convalescent, but the man-servant is very ill. If, during cooking, the flesh consumed by these persons had been raised to a persistent temperature of 170° Fahr., then, doubtless, the ingestion of trichinised pork would have done no harm. You observe that Dr Dickinson says in his letter that they partook of it roasted and boiled. Now, few of us are in the habit of eating underdone pork, although there are other meats that we devour very readily in an imperfectly cooked state. It must be remembered, also, that although the exterior may have been subjected to a temperature of 212 degrees, it by no means follows that the whole of the joint throughout must have been submitted to that temperature. Under rapid cooking, the centre of a large joint may remain much below even 140 degrees. If the man-servant ate only one ounce of the flesh with living Trichinæ in it, he will probably have at this present moment at least 42,000,000 of these guests in his muscles. You will ask, 'Will he recover?' 'Yes; if he ate no more than that.' If he has eaten 2 oz. thoroughly underdone, depend upon it he has 80,000,000, and if he has eaten 3 oz. he will have over 100,000,000 of Trichinæ in his muscles. Could he survive if he had eaten over 3 oz., and thus have 100,000,000 and upwards of these inhabitants? I think he could. We have evidence on this point from the case in which I estimated that there were upwards of 100,000,000 of Trichinæ present, and yet the man survived the attack.

"Incidentally I may remark that in the course of the last twenty years, although millions of parasites and their eggs have passed through my hands, I have almost entirely escaped infection. It is something to know what you are either handling or looking at, because there are many parasites besides Trichina which are dangerous. There are gregariniform entozoa residing in meat which we eat every day without any bad consequences. They are as harmless as cheese-mites. There is no need to be in the slightest degree nervous about flesh-food, provided it is properly cooked. I believe there will be no fatal issue in the case of any of the three individuals just alluded to, but the chief practical point before us arises out of the fact that we have here, for the first time in England, an epidemic of trichiniasis. By calling attention to the subject, it will, to say the least, suggest precautions by which future epidemics may be avoided."

The above remarks form the substance of a lecture given on the 24th of April, 1871. A week later I delivered the third of the Cantor lectures for that year, when I took occasion to add the following particulars:

"It has been asked whether the so-called muscle-Trichinæ, after they have arrived at their destination within the flesh of man, are capable of producing any more unfavorable consequences? The answer is, Certainly not. In the case of man it would be necessary that his muscles should be eaten in order for the Trichinæ to become sexually-mature worms; and in those countries where cannibalism exists, the man-eater would himself become trichinised, and would certainly deserve his fate. I was very desirous to follow up the account of this outbreak by inquiries respecting the particular animal which had been the cause of the outbreak. I may therefore mention that my informant, Dr Dickinson, states that the family, including the man-servant, all fed together, and that they had for upwards of a fortnight eaten daily, and sometimes twice a day, sausages made from the flesh of the trichinised animal. And he adds: The meat cut from the ham and flitches, and what is called the spare-rib, was roasted before the fire or in the frying-pan. Occasionally it was cooked in the oven. Dr Dickinson ascertained from the mother that she liked her meat to be underdone, and thus, therefore, there is very little doubt that the meat was generally undercooked. The man, a strong labourer, had a good appetite, and would

therefore get a large share. He is improving slowly. Dr Dickinson adds in a postscript, what is still more to the point, that the sausages would be most likely undercooked; they would be cooked in the frying-pan, and if only brown on the outside would be eaten. It is probable that the outbreak was due therefore to eating underdone meat from this pig, cooked in various ways, and not alone from the ham itself."

If the facts connected with this outbreak be honestly faced, it must be rendered clear to any unprejudiced observer that Dr W. Lindow Dickinson was the first person to observe, recognise, and treat the Trichina disorder in this country. No other English, Scotch, or Irish physician has encountered any similar case. If I lay stress upon this fact it is because I have learned from Dr Dickinson that another person has asserted priority in this relation. Sir Dominic Corrigan is stated to have told a gentleman in the House of Commons, "that he had often met with trichiniasis in his practice in Dublin," further averring that the disease "was quite common in many parts of Ireland." If Sir D. Corrigan merely desired it to be understood that he had repeatedly encountered the Trichina at post-mortem examinations, then there is nothing surprising in his statement, but if, on the other hand, the disease itself has been frequently recognised in the living Irish human subject, one can only express astonishment that hitherto no single instance of the kind appears to have been recorded either in the public or professional journals.

Bibliography (No. 21).—*English Literature.*—*Allman, G. J.*, "Exhib. of Specimens," 'Micr. Jrn. and Structural Record,' 1842, p. 94.—*Althaus, J.*, 'Essay on Trichinosis,' London, 1864.—*Idem*, "On a Suspected Case," 'Med. Times and Gaz.,' 1864, p. 161; see also pp. 362 and 390.—*Atwood*, see *Belfield*.—*Ballard, E.*, "On Diseased Meat," 'Med. Times and Gaz.,' 1864.—*Belfield* (with *Atwood*), "Trichinæ in Pork;" 'New York Med. Rec.,' Dec. 28, 1878; 'Med Times and Gaz.,' Feb. 15, and 'Lancet,' Feb. 22, 1879.—*Bellingham, O. B.*, 'Dublin Med. Press,' 1852.—*Bowditch, H. J.*, "Cases of Trichina," 'Boston Med. and Surg. Journ.,' 1842-43-44.—*Bristowe, J. S.* (and *Rainey*), 'Trans. Path. Soc.,' 1854.—*Chevers, N.*, "Sanitary Efforts in regard to Trichiniasis," 'Lancet,' 1864, vol. ii, p. 733.—*Cobbold, T. S.*, "On the Discovery of Trichina, in relation to the question of Priority," 'Lancet' for March 3, 1866, p. 244.—*Idem*, 'Parasites, and the part they play in the Economy of Nature' (lecture), Manchester,

1873, p. 46; also in the 'Veterinarian,' March, 1874.—*Idem*, Remarks in the 'Journ. Soc. of Arts,' 1866, p. 399; also in 'Med. Times. and Gaz.,' 1867, p. 24; also in 'Lancet,' Feb., 1864 and 1866, p. 538.—*Idem*, 'Our Food-producing Ruminants and the Parasites which reside in them' (Cantor Lectures), 1871.—*Idem*, "Experiments with Trichina," 'Proceed. Linn. Soc.,' vol. ix, p. 205, 1867; see 'Lancet' for Jan. 13, 1866, p. 52; 'Brit. Med. Journ.' for Dec. 22, 1866, p. 713; also 'Lancet' for Jan. 9, 1867, p. 91.—*Idem*, "Worms" (l. c., Bibliog. No. 2, Lecture xviii), 1872.—*Idem*, "Outbreak of Trichinosis in England," 'Brit. Med. Journ.,' 1871, p. 435.—*Idem*, "Trichinæ in Fish" (alleged to have been found in a pike by Dr. Elendenen at Ostend), in the 'Lancet' (anonymous annotation) for Nov. 16, 1878.—*Curling, T. B.*, two cases, 'Lond. Med. Gaz.,' 1836.—*Davaine, C.*, quoted in 'Brit. Med. Journ.,' see foreign lit., below.—*Delpech*, abstr. of his Report, 'Brit. Med. Journ.,' 1866, p. 375.—*Dickinson, W. L.*, 'Brit. Med. Journ.,' 1871.—*Elendenen*, "Trichinæ in Fish" (newspaper report respecting his "find"); see Cobbold, above.—*Farre, A.*, "Observations," 'Lond. Med. Gaz.,' 1835-36.—*Friedreich, N.* (trans. by Ogle), 'Med.-Chir. Rev.,' 1863, repr. in 'Edin. Vet. Rev.,' 1863.—*Furstenburg*, 'Edin. Vet. Rev.,' 1864, p. 513. —*Gordon* (see Chevers).—*Gamgee, J.*, "On Diseased Meat," 'Pop. Sci. Rev.,' 1864.—*Goodsir, J.*, 'Month. Journ. Med. Sci.,' 1842.—*Harr*, 'Bost. Med. and Surg. Journ.,' 1866, p. 532.—*Harrison*, "On a peculiar Species of Entozoon occasionally found in the Voluntary Muscles of the Human Subject," 'Rep. of Brit. Assoc.,' Aug. 12, 1835; in 'Dub. Journ.,' vol. viii, 1835-36; in 'Lond. and Edin. Phil. Mag.,' and in 'Amer. Journ. Med. Sci.,' vol. xviii, p. 187, 1836.—*Herbst*, "Trichinæ in the Badger," 'Assoc. Med. Journ.,' 1853, p. 491.—*Hilton, J.*, "Notes on a peculiar appearance observed in Human Muscle, probably depending upon the formation of very small Cysticerci," 'Lond. Med. Gaz.,' vol. xi, p. 605, 1833.—*Jackson, J. D.*, "Trichiniasis," in 'Hay's Amer. Journ.,' 1867, p. 82.—*Kiefer, H.*, cases, 'Bost. Med. and Surg. Journ.,' 1866, p. 208.—*Kobelt*, 'Micr. Journ. and Struct. Rec.,' 1842, p. 147.—*Kratz*, "On the Hedersleben Epidemic," 'Brit. Med. Journ.,' 1866, p. 76.—*Krombein*, "Trichiniasis in New York," 'Amer. Journ. Med. Sci.,' 1864, and 'Med. Times and Gaz.,' 1864, p. 292.—*Küchenmeister, F.*, Symptoms, &c., 'Lond. Med. Rev.,' 1860, p. 457.—*Langenbeck*, case, 'Edin. Vet. Rev.,' Feb., 1864.—*Leidy, J.*, "Trichina in

the Pig," 'Annals of Nat. Hist.,' and 'Pr. Ac. N. S. Philad.,' 1847.—*Leuckart, R.* (translations from), in 'Ann. Nat. Hist.,' 1860; in 'Qrt. Journ. Micr. Sci.,' 1860; and in 'Bost. Med. and Surg. Journ.,' vol. liii, p. 198, 1860-61.—*Liveing, R.*, "Path. Soc. Rep." in 'Med. Times and Gaz.,' 1865, p. 374.—*Mosler*, "On Trichinous Flesh," 'Brit. Med. Journ.,' 1864, p. 554.—*Idem*, "On Benzine in Trichinosis," 'Med. Times and Gaz.,' Oct., 1864, p. 444.—*Nunneley, T.*, 'Brit. Med. Journ.,' 1866, p. 252. —*Owen, R.*, "Description of a Microscopic Entozoon infesting the Muscles of the Human Body," 'Proc. Zool. Soc.,' and 'Lond. Med. Gaz.,' 1835; 'Trans. Zool. Soc.,' vol. i, 1835.—*Idem*, Remarks in 'Journ. Soc. of Arts,' 1866, p. 399.—*Paget, J.*, "Letter relating to the Discovery of Trichina," 'Lancet,' March, 1866, p. 269.—*Rorie, J.*, Letter, 'Lancet,' Feb., 1864.—*Salisbury, J. H.*, On a supposed Species of Trichina (*T. cystica*) from the Human Bladder; in his paper on "Parasitic Forms," in 'Hay's Amer. Journ. Med. Sci.,' 1868, p. 376.—*Sanders, R.*, 'Edin. Month. Journ.,' 1853.—*Sawer, A.*, 'Bost. Med. and Surg. Journ.,' 1865, p. 16.—*Sutton, G.*, Report on Trichinosis; Indiana, U.S., 1874. — *Thudichum, J. W. S.*, 'Brit. Med. Journ.,' Jan., 1864, repr. in 'Glasgow Med. Journ.,' April, 1864, p. 116; also letter in 'Edin. Med. Journ.,' Feb., 1864.— *Idem*, "Rep. on the Parasitic Diseases of Quadrupeds used as Food," pub. by the Med. Officer of the Privy Council, London, 1865.—*Idem*, "The Diseases of Meat as affecting the Health of the People," 'Journ. Soc. of Arts,' April 20, 1866.—*Idem*, "German Sausages and the Trichina Disease," 'Scientific Opinion' for April 25, 1866.—*Idem*, 'Lancet' for Jan. 6, 1866, p. 16.—*Turner, W.*, "On the *Trichina spiralis*," 'Edin. Med. Journ.,' Sept., 1860; in the 'Year-Book,' p. 109, for 1860; in 'Med.-Chir. Rev.,' 1862; and in 'Bost. M. and S. Journ.,' vol. lxiii, p. 294.—*Ude*, "Rep. on the Inspection of Pigs," 'Med. Times and Gaz.,' Aug., 1868, p. 141. —*Valentin*, 'Micr. Journ. and Struct. Rec.,' 1842, p. 87.— *Virchow, R.*, Extr. from his brochure on '*Trichina*' (by myself), in 'Gunther's Record' for 1864, p. 611.—*Idem*, "On the Cure of Trichinosis," 'Brit. Med. Journ.,' April, 1866, p. 368.—*Idem*, from "Comptes Rendus," in 'Qrt. Journ. Micr. Sci.,' 1861.— *Idem*, from his 'Archiv,' 1860, Bd. xviii, Heft. 4, p. 330; in 'Brit. and For. Med.-Chir. Rev.,' vol. xxvi, p. 515, 1860.— *Wedl*, Report, 'Brit. Med. Journ.,' Dec., 1866, p. 618.—*Wilks, S.*, "Letter respecting the Discovery of Trichina," 'Lancet,'

March 10, 1866, p. 269; see also the 'Times,' Feb. 13, 1866.—*Windsor, J.*, 'Brit. Med. Journ.,' March 4, 1866, p. 319.—*Wood, H.*, case, 'Lond. Med. Gaz.,' 1835.

Foreign Literature:—*Ardenghi, E.*, "Sulla *Trichina spiralis*," 'Lo Studente Veterinario,' 1876, p. 115.—*Behrens*, "Ein Fall von Trichiniasis," 'Deutsche Klinik,' No. 30, 1863 (quoted by Davaine).—*Bette, F.*, *ibid.*, 1876.—*Bischoff*, 'Path. Anat. des menschl. Körp.,' 1845.—*Idem*, 'Med. Annalen,' 1840.—*Böhler*, 'Die Trichinenkrankheit in Plauen,' 1863.—*Boudin*, "Des épidémies de Trichina spiralis observées en Allemagne dans ces dernières années," 'Journ. de Méd. Vét. Milit.,' August and September, 1864 (quoted by Davaine).—*Claus*, 'Wurzb. nat. Zeitschr.,' 1860.—*Idem*, 'Ueber die Trichine' (a discourse), 1877.—*Colberg*, 'Deutsche Klinik,' 1864.—*Davaine, C.*, 'Traité' (l. c., Bibl. No. 1), 1860, p. 672, 2nd edit., p 732—768.—*Idem*, "Faits et Considerations sur la Trichine," 'Mémoires de la Société de Biologie' for the year 1862, tom. iv, ser. 3, 1863; in 'Gazette Médicale de Paris,' 1863; in 'British Medical Journal' for April 25, 1863; and in my 'Entozoa,' p. 349.—*Idem*, "La Trichine" (popular exposition), in 'Revue des Deux Mondes' for May, 1865. — *Dujardin* (l. c., Bibl. No. 1), p. 24.—*Fiedler*, 'Virchow's Archiv,' 1864.—*Fleckles, F.*, 'Die Trichinen und die Trichinenkrankheit' (popular exposition), Prag., 1866 (quoted by Davaine). — *Friedrich, N.*, 'Virchow's Archiv,' 1862.—*Fürstenberg*, "Wochenblatt d. Ann. der Landwirthsch., in d. Königl. Preuss. Staaten," 1865.—*Gerlach, C.*, 'Die Trichinen,' 1866.—*Idem*, 'Hannöversche Zeitschrift,' 1864. — *Hagen*, in 'Pharmaceutische Centralhalle,' 1862.—*Henle*, 'Muller's Archiv,' 1835, s. 526.—*Herbst*, 'Nachrichten v. d. Georg-Aug. Univ. zu Göttingen,' 1852; 'L'Institut,' 1852, p. 135. — *Heschl, R. L.*, 'Ueber Trichinen, die Trichinenkrankheit und die Schützmassregeln dagegen,' Gratz, 1866 (quoted by Davaine).—*Kestner*, "Etude sur le Trichina," 'Gaz. Méd. de Paris,' 1864.—*Klusemann*, "Die Erkrankung durch den Genuss von Nahrungsmittel aus dem Thierreiche," 'Deutsche Klinik,' 1864.—*Kobelt*, 'Valentin's Repertorium,' 1841.—*Krabbe*, "Husdyrenes Indvoldsorme," 'Tiddsskrift for Vet.,' 1872.—*Kratz*, 'Die Trichinenepidemie zu Hedersleben,' 1866.—*Küchenmeister*, 'Parasiten,' 1855.—*Leuckart*, 'Untersuchungen ueber *Trichina spiralis*,' 1866.—*Idem*, "Die mensch. Par.,' Bd. ii, s. 409.—*Idem*, "Die neuesten Entdeckungen ueber menschliche Eingeweidewürmer

und deren Bedeutung für die Gesundheitspflege," 'Unsere Zeit.,' 1862.—*Lion,* 'Zur Geschichto, Therapie, Prophylaxis, und Sanitätspolizei der Trichinen' (quoted by Pagenstecher).—*Luschka,* "Zur Naturgeschichte der *Trichina spiralis,*" 'Zeitschr. für wissenschaftl. Zool.,' 1851.—*Meissner,* 'Zeitschr. f. rat. Med.,' 1855.—*Idem,* "Ueber Trichinenkrankheit," 'Schmidt's Jahrbücher,' 1863.—*Ordonez, E. L.,* 'Note sur la Distinction des Sexes et le Développement de la Trichina spiralis des Muscles,' Paris, 1863; and 'Compt. Rend. Soc. Biologie,' p. 61, 1863 (quoted by Davaine).—*Pagenstecher,* 'Verhandl. d. Naturhist.-Med. Vereins zu Heidelberg,' 1864.—*Idem* (und *Fuchs*), 'Die Trichinen,' 1865.—*Perroncito,* "La *Trichina spiralis*" in 'Italia. Estr. degli Annali R. Accad. d'Agric. di Torino,' vol. xx, 1877.—*Reyher, O.,* 'Die Trichinenkrankheit,' Leipzig, 1862.—*Rodet, H.,* 'De la Trichine et de la Trichinose,' Paris, 1865 (quoted by Davaine).—*Rupprecht, B.,* 'Die Trichinenkrankheit im Spiegel der Hettstedter Endemie betrachtet,' Hettstedt, 1864.—*Seidel,* 'Jenaische Zeitschr. f. Med. u. Nat.' 1864.—*Siebert,* 'Ueber die Trichinenkrankheit und ihre Vermeidung,' Jena, 1863—*Siebold,* art. "Parasiten," 'Wagner's Handwörterbuch,' 1844.—*Simon, G.,* "Eine Trichinen-epidemie in Calbe," 'Preussische Medicinal Zeitung,' 1862.—*Tommasi,* 'La Trichina spiralis e la Malattia prodotta da esso,' Torino, 1863.—*Tüngel,* 'Archiv von Virchow,' xxvii, 3, 421, 1863 (quoted by Davaine).—*Virchow,* 'Deutsche Klinik,' 1859; 'Comptes Rendus de l'Acad. des Sci.,' tom. xlix.—*Idem,* 'Archiv f. Path. Anat. und Physiol.,' Bd. xviii.—*Idem,* 'Darstellung der Lehre von den Trichinen' (fur Laien und Aerzte), 1864.—*Vogel,* 'Die Trichinenkrankheit,' 1864.—*Wagner,* "Eine Trichinenepidemie in Leipzig," 'Arch. der Heilkunde,' 1864.—*Wunderlich, C. A.,* "Sur la diagnose probable de l'affection trichinale," 'Gaz. Méd. de Paris,' p. 311, 1863; from 'Wagner's Archiv der Heilkunde,' ii, 3, p. 269, Leipzig, 1861 (quoted by Davaine).—*Zenker,* "Zur Lehre von der Trichinenkrankheit," 'Deutsches Archiv. für Klin. Med.,' Bd. viii, s. 387.—*Idem,* 'Virchow's Archiv,' 1855 and 1860.

Trichocephalus dispar, Rudolphi.—This well-known worm possesses a long filiform neck, occupying about two thirds of the entire length of the body. The surface of the skin though smooth to the naked eye is furnished on one side with a longitudinal band of minute wart-like papillæ. The tail of the male

is curved, and emits at the extremity a short, tubular penis-sheath, armed with minute retroverted spines. The tail of the female is straight and bluntly pointed. The eggs measure $\frac{1}{480}''$ to $\frac{1}{447}''$ in their long diameter. The whipworm infests the cæcum, and also the upper part of the colon. Upwards of one thousand were found by Rudolphi in a woman.

The original name of *Trichuris*, given to this worm by Buttner, could not, of course, be allowed to stand when it became evident that the so-called tail was in reality the head and neck. The *Trichocephalus* is not uncommon in England and Ireland. It is less frequent in Scotland. On the continent, however, it is so abundant that M. Davaine calculates that not less than one half of the inhabitants of Paris are infested by it. From what Dujardin has said it can be scarcely less abundant in Northern France, for M. Duval, the distinguished director of the Rennes School of Medicine, supplied that helminthologist with numerous specimens on various occasions. The worm abounds in Italy and Egypt; being scarcely less prevalent in the United States. The lamented Mr Noel, one of my old pupils at the Middlesex Hospital College, brought me specimens which he found post-mortem on three or four occasions. Dr Haldane, of Edinburgh, once or twice obtained large numbers (post-mortem). In Ireland, Bellingham found the worm in eighty-one out of ninety post-mortem examinations. Mr Cooper, of Greenwich, met with it, post-mortem, in eleven out of sixteen instances. When treating patients for tapeworm I have repeatedly expelled the whipworm.

The organisation of *Trichocephalus dispar* has been investigated by Dujardin, Mayer, Von Siebold, Eberth, Bastian, and others. Prof. Erasmus Wilson and myself have carefully studied the anatomy of the closely-allied whipworm of ruminants (*T. affinis*) which is discussed in my 'Entozoa.'

The statement of Küchenmeister that there are no external appendages in the female *Trichocephalus* comparable to those known to exist in the allied *Trichosomata*, is incorrect. Leuckart's, and especially Virchow's, researches disproved Küchenmeister's and Meissner's notion that *Trichinæ* were the young of *Trichocephalus*. The experiments of Davaine render it probable that the young get into the human body in a direct manner. He finds that the eggs undergo no development whilst yet lodged within the host's intestines. The eggs are

expelled per anum in the immature condition in which they first escape from the body of the parent worm. It further appears that, after their expulsion, a period of six months must elapse before embryonic formation commences. The fully-developed embryo measures $\frac{1}{333}''$ in length, and resembles the parent to a certain extent.

Whipworms rarely put their bearers to inconvenience; nevertheless, both human and animal hosts occasionally suffer from their presence. Thus, Felix Pascal quotes a remarkable and fatal instance of cerebral symptoms from this cause in a girl of four years of age; and Mr Gibson has recorded an instance in which these worms produced paralysis and loss of speech. According to Professor Axe, sheep suffer severely from the allied species.

Bibliography (No. 22).—*Bastian, H. C.*, "On the Anatomy of the Nematoids," 'Phil. Trans.,' 1866, p. 545.—*Bellingham, O. B.*, "On the frequency of *Trichocephalus dispar* in the Human Intestines," 'Rep. of Brit. Assoc., in Dubl. Journ.,' 1838, and in 'Med. Chir. Rev.,' 1838; see also Bibliog. No. 33 (and the biography of Bellingham by Dr Mapother, in 'Dubl. Jrn. Med. Sci.,' 1877, p. 471).—*Busk, G.*, "Anat. of *T. dispar*," 'Ann. Nat. Hist.,' vol. vii, 1841.—*Chiaje*, sul *Tricocephalo disparo*, &c., 1836.—*Cobbold*, 'Entozoa,' pp. 69 and 329.—*Idem*, 'Worms,' pp. 31 and 67.—*Davaine*, l. c., p. 205.—*Idem*, 'Compt. Rend.,' 1858, p. 1217, and 'Journ. de Physiol.,' 1859, p. 296.—*Dubini*, 'Entozoografia umana,' p. 83.—*Dujardin*, l. c., p. 32. — *Eberth*, "Die Generationsorgane von *T. dispar*," 'Sieb. und Köll. Zeitschr.,' 1860, s. 384.—*Gibson, D.*, "On a Case of Paralysis, with loss of speech, from intestinal irritation (produced by *T. dispar*), 'Lancet,' Aug. 9th, 1862, p. 139.—*Goeze*, 'Naturg.,' s. 112.—*Gurlt*, 'Path. Anat.,' p. 350.—*Küchenmeister*, l. c., s. 235; Eng. edit., p. 321.—*Leidy*, 'Proc. Acad. Phil.,' viii, p. 53.—*Leuckart*, l. c., s. 465.—*Mayer*, Sieb. und Köll. 'Zeitsch. f. wiss. Zool.,' Bd. ix, s. 367; Bd. x, s. 233, and s. 383, 1858-60.—*Mérat*, 'Dict. Sc. Méd.,' p. 560.—*Von Siebold*, 'Wiegm. Arch.,' 1845.—*Wilson, E.*, 'The Veterinary Record and Trans.,' vol. ii, p. 47, 1846.

Filaria Bancrofti, Cobbold.—The history of the discovery of this entozoon is second only in interest to that of *Trichina spiralis*. Step by step the facts have been evolved by a slow process of observation, and from the data thus afforded a tolerably connected narrative of the probable life-cycle of this

entozoon may now be offered. To place matters beyond all doubt much remains to be done; yet that which has been accomplished is, or ought to be, of surpassing interest alike to the physician, the scientific pathologist, the epidemiologist, and the philosophic naturalist. In the case of Trichina, Owen's nomenclature was most properly allowed to stand; but for reasons stated below I have not hesitated to employ for this worm, in its adult state, a name differing from that originally given to the hæmatozoon which turns out to be its representative larval state. Although the male parasite is at present unknown, the following characters will in the meantime suffice for a diagnosis of the species :—Body capillary, smooth, uniform in thickness. Head with a simple circular mouth, destitute of papillæ. Neck narrow, about one third of the width of the body. Tail of female simple, bluntly pointed; reproductive outlet close to the head; anus immediately above the tip of the tail. Length of largest females, $3\frac{1}{2}$ in.; breadth, $\frac{1}{90}''$; embryos, $\frac{1}{200}''$ to $\frac{1}{125}''$ in length, by $\frac{1}{3000}''$ to $\frac{1}{2250}''$ in breadth; eggs, averaging $\frac{1}{1000}''$ by $\frac{1}{1650}''$ from pole to pole.

The first discovery of this entozoon, in its embryo state, was made by Wucherer on the 4th of August, 1866. To use Dr Da Silva Lima's words :—"At the moment when Wucherer was seeking for the *Bilharzia hæmatobia*, he found instead of it an unknown worm. Our illustrious collaborator," adds Dr Lima, "has made his important discovery known under the modest title of 'Preliminary Notice on a species of Worm at present not described;' and still more modestly Wucherer formulated in the following manner his judicious and prudent conclusions :—It would be rash on my part to put forth a conjecture on the coexistence of these worms of the hæmatochyluria, and on the etiological signification which they might have. I shall therefore abstain until I have been able to make more ample investigations, and until I have been permitted to examine the corpse of a hæmaturic, which has not yet been possible." ('Gazeta Medica da Bahia,' Dec., 1868, p. 99.)

In the year 1868 Dr J. H. Salisbury referred certain ova which he found in the urine to a new and distinct species of nematode. Although he had no acquaintance with the adult parasite, Dr Salisbury at once placed the "species" in the genus Trichina. Here is what he says :—"*Trichina cystica* (Salisbury).—This is a small species which I have found in the

human bladder. In all my examinations I have met with this little entozoon in three cases only. In two of these it was only occasionally met with in the urine. In the other it occurred in great numbers. Frequently from ten to fifteen ova were found in a single drop of urine."

It is important to remark, that there was no hæmaturia in the last-named case, which Dr Salisbury describes as one of "cystinic rheumatism," or "severe cystinæmia associated with rheumatism and paralysis." The patient "had been insane for several years. Her urine was passed milky, with granular cystine, and was dense and scanty." It is likewise added: "No examination was made of the muscles after death to determine whether this species burrowed in the tissue, like the (*Trichina*) *spiralis*."

So much for the principal facts recorded by Dr Salisbury. His paper is accompanied by two woodcut figures of the ova ($\times$ 300 diam.), and one representation of the embryo ($\times$ 1000 diam.). If these figures give the size correctly, the ova measure only about $\frac{1}{800}''$ in length, by $\frac{1}{1500}''$ in breadth, whilst the embryo would be about $\frac{1}{500}''$ from head to tail.

On the 17th of May, 1872, I communicated to the Metropolitan Counties Branch of the British Medical Association a paper on '*Bilharzia*,' and in an Appendix to it I wrote as follows:—"A most interesting circumstance connected with this case of '*Bilharzia*' from Natal lies in the fact that I obtained from the patient some other urinary parasites in the egg-condition (fig. 38). On five separate occasions I obtained one or more specimens of the eggs or embryos of a minute nematode. In one instance there were about fifty of these ova in the urine, their contained embryos being well developed and in a state of activity. Usually they were all in this advanced condition; but on the 25th of July, 1870, several were observed in much earlier stages of development. One of these was of a triangular form; its shape, granular contents, and clearly defined limiting membrane, indicating separation from the rachis within the ovarian tube. Another early form was perfectly spherical, with a well marked chorional envelope and double contour. These forms measured about $\frac{1}{750}''$ in diameter. The fully grown eggs observed at the same time gave a longitudinal measurement of $\frac{1}{500}$ by $\frac{1}{1000}''$ in breadth. On adding any stimulus, such as diluted sulphuric acid, the embryos moved themselves freely within the egg. After allowing the

urine to stand for forty-eight hours, I found, on the 27th of July, that the shells of the ripe ova had dissolved, leaving the embryos dead, but still coiled within a fine transparent envelope. In this state they were easily separated and examined, when they gave a measurement of $\frac{1}{300}''$ in length, by $\frac{1}{3500}''$ in breadth. On two occasions, whilst engaged in rearing the larvæ of *Bilharzia* in water, I noticed single specimens of these embryos lying dead; and one of the examples thus observed gave a length of $\frac{1}{150}''$, by $\frac{1}{3000}''$ in breadth."

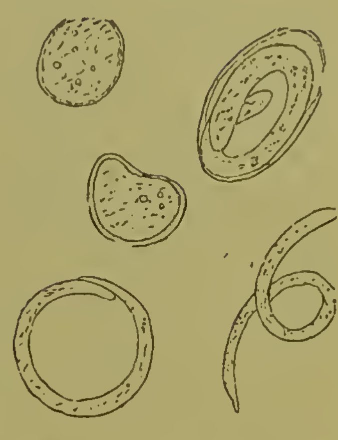

FIG. 38. — Group of eggs and embryos in a case of endemic hæmaturia (1870). Original.

Knowing what errors of interpretation have often crept into helminthological literature I was more than usually cautious in pronouncing upon the source of these urinary parasites. Accordingly, I remarked that "future discoveries might enable us to identify the species of nematode to which these ova are referable." I also added :—" Notwithstanding discrepancies as to size, I am inclined to think that Dr Salisbury and myself have been made acquainted with nematode eggs and embryos referable to one and the same species of parasite. I do not care to speculate as to the origin of these ova. Long ago I gave in my adhesion to the determinations of Schneider in respect of the so-called *Spiroptera hominis*, but I am by no means certain that his position may not be disturbed by fresh discoveries. It is not a little remarkable that the parents of my patient should have averred that she passed three small vermiform entozoa by the urethra, corresponding, to judge from their verbal statements, very closely with the ordinary appearances of *Filaria piscium*."

Having written thus much seven years back, it is with natural pleasure that I find my anticipations already verified. Knowing that I was dealing with parasites in their earliest larval stages, it never occurred to me to give a specific name to them, and I could not possibly approve of Dr Salisbury's nomenclature, for which there was no good ground.

In the original discovery Dr O. Wucherer procured the worms from the chylous urine of a female in the Misericordia Hospital at Bahia; and on the 9th of the following October, 1866, he obtained similar worms from another female suffering from

hæmaturia. He also afterwards found them in a man whose urine was slightly chylous, but not hæmatic. In all cases these sexually-immature nematodes were alive. In September, 1872, Dr A. Corre furnished a careful description of similar worms found by Dr Crévaux in a hæmato-chylurous patient at Guadeloupe. Dr Crévaux frequently examined the blood of this patient but found no hæmatozoa. In like manner in Brazil, Dr J. Silva Lima sought in vain for worms in the blood of no less than five patients, all of whom suffered from hæmaturia, and whose urine contained numerous nematoid worms.

Towards the close of the year 1872 the biological world was startled by the announcement of the discovery of minute Filariæ in human blood. Dr T. R. Lewis had found microscopic worms in the blood, and also in the urine, of persons suffering from chyluria. The worms could be obtained from day to day by simply pricking any portion of the body with a finely pointed needle. To this hæmatozoon Lewis gave the trinomial term *Filaria sanguinis hominis*, which thus fitly distinguished it from the *Filaria papillosa hæmatica canis domestici* described by Grube and Delafond. Dr Lewis found the average size of the parasite to be $\frac{1}{75}''$ in length by $\frac{1}{3500}''$ in breadth. He observed that while it exists in the blood the body is enclosed in a delicate transparent tunic or cyst. The worm was never absent from urine in chyluria. In a case in which there was a milky discharge from the eyes the worms were also detected. In one case Lewis calculated that 140,000 Filariæ were present in the blood—a number certainly not relatively large seeing that MM. Grube and Delafond estimated the verminiferous blood of their several dogs to contain numbers varying from 11,000 to 224,000. Lewis also found Filariæ in the kidneys and supra-renal capsules of a woman who died of chyluria. It did not appear probable that the worms underwent further development in the human body. On this point Lewis remarks :—"Not only may those hæmatozoa found in man live for a period of more than three years, but there is no evidence that they have any tendency to develop beyond a certain stage as long as they remain in the circulation." Dr Lewis judged that the form of chyluria associated with this condition of the blood was local and intimately related with a tropical climate. The milky condition of the urine comes on suddenly, not only at first, but on succeeding occasions also. It is frequently accompanied by more or less distinctly marked symptoms of various other

obscure diseases, including temporary swellings in the face or extremities. From certain appearances of intestinal ulceration Lewis thought that the parasites might gain access to the system by the alimentary canal, possibly from the tank-water or the fish inhabiting it. He considered the state of the urine to be due to the mechanical interruption offered to the flow of the nutritive fluids of the body. The accidental aggregation of the Hæmatozoa might give rise to obstruction of the currents within the various channels, or occasion rupture of their extremely delicate walls, and thus cause the contents of the lacteals, lymphatics, or capillaries, to escape into the most conveniently placed excretory channel.

Compressed into a small compass, I think the above is a fair statement of the leading facts and phenomena discovered by Lewis. The whole subject of hæmatozoology immediately received additional impulse, the consequences of which have not yet terminated. In this country Welch was stimulated to investigate the structure of *Filaria immitis* in the dog, whilst others sought diligently for nematoid hæmatozoa abroad.

On the 20th of April, 1874, Dr Prospero Sonsino communicated to the Neapolitan Royal Academy his memoir entitled "Researches concerning *Bilharzia hæmatobia* in relation to the endemic hæmaturia of Egypt, with a notice concerning a nematoid found in the human blood." In this brochure he made known the fact of his having discovered microscopic Filariæ in a young Egyptian Jew, in the following words:—"On the 1st of February last, having well washed the finger of the boy, I placed one drop of blood under the microscope, when with astonishment I discovered a living organism of the form of a nematode, resembling *Anguillula*, in the midst of the hæmatic corpuscles. The worms glided amongst the globules, which were tossed about by their lively movements, showing various appearances according as they presented themselves either from the sides, the edges, or the front of the disk" ('Ricerche,' &c., pp. 11, 12). Dr Sonsino took every precaution to prevent error, subsequently verifying his "find" from the same patient. Dr Sonsino directs attention to two of his own characteristic figures of the worm, and subsequently states not only that he found examples of the Filariæ in the urine of this same youth, but also "in the urine of another patient." The parasites from these two sources being figured side by side, it was clear, from their resemblance, that they referred to one and the same species of entozoon. Dr

Sonsino having compared the facts supplied by these cases, was satisfied that the nematodes in question were specifically identical with those that I had previously obtained from my little African patient. However, Dr Sonsino was of opinion that his Filariæ were not precisely the same as those that had been described by Lewis.

On the 8th of April, 1876, I received from Dr William Roberts, of Manchester, some capillary tubes, charged with blood, obtained from a patient suffering from chyluria. The tubes had been transmitted by Dr Bancroft, of Brisbane, Queensland, Australia; and in fulfilment of the donor's request, Dr Roberts afforded me an opportunity of examining their contents, he having himself verified Bancroft's statement that they contained Filariæ. It was not until May 22nd that I found opportunity to confirm the observations of Drs Bancroft and Roberts. The contents of some of the tubes had by this time completely dried up; but in others, to which diluted glycerine had been added, the blood appeared tolerably fresh. In what might be reckoned as the sixth part of the contents of one of the tubes, spread on a glass slide, I detected about twenty Filariæ, three of which I sketched *in sitû*, in order to compare them with the figures of Lewis, and also with others that I had procured from my *Bilharzia*-patient in the year 1870. There could not, I thought, be any doubt as to the identity of all these sexually-immature nematoids. One novelty, however, presented itself in the presence of a solitary and empty egg envelope, measuring about $\frac{1}{500}$ of an inch in its long diameter, and thus corresponding precisely with the ova that I obtained from the urine in my *Bilharzia* case.

According to Bancroft, chyluria is somewhat common in Brisbane; and the case here brought forward was not the only one of the kind which had already furnished Filariæ in the blood. The patient was a little girl ten years of age.

Thus stood the facts in the spring of 1876. Having informed Dr Bancroft that a nematoid egg had been detected in the Australian blood transmitted to England, he was induced to make further investigations. These happily resulted in the discovery of the adult worm; the circumstances attending the "find" being recorded by Dr Bancroft in a letter written to myself and dated from Brisbane, Queensland, April 20th, 1877. He wrote as follows:—"I have labored very hard to find the parental form of the parasite, and am glad to tell you that I

have now obtained five specimens of the worm, which are waiting to be forwarded by a trustworthy messenger.

"I have on record about twenty cases of this parasitic disease, and believe it will be the solution of chyluria, one form of hæmaturia, one form of spontaneous lymphatic abscess, a peculiar soft varix of the groin, a hydrocele containing chylous fluid, together with some forms of varicocele and orchitis. These I have verified. In the colony there are no cases that I can find of elephantine leg, scrotal elephantiasis, or lymph scrotum; but from the description of these diseases in the volume on skin and other diseases of India by Fox, Farquhar, and Carter, and from Wm. Roberts' article on the latter in his volume on urinary diseases, I am of opinion that the parasitic nature of the same will be established.

"The worm is about the thickness of a human hair, and is from three to four inches long. By two loops from the centre of its body it emits the Filariæ described by Carter in immense numbers.

"My first specimen I got on December 21st, 1876, in a lymphatic abscess of the arm; this was dead. Four others I obtained alive from a hydrocele of the spermatic cord, having caught them in the eye of a peculiar trochar I use for tapping. These I kept alive for a day and separated them from each other with great difficulty. The worm when immersed in pure water stretches itself out and lies quite passive. In this condition it could be easily washed out of hydroceles through a large-sized trochar from patients known to suffer from Filariæ."

In July, 1877, I announced Bancroft's discovery in the 'Lancet,' naming the parasite *Filaria Bancrofti*, and in the following September I sent the editor an account of the results of my study of the adult worms received from Brisbane in the interval. These examinations supplied me with the diagnosis already given (p. 181).

On the 29th of September, 1877, Dr Lewis published a paper in the 'Lancet,' wherein, after alluding to my previous announcement respecting the discovery of *Filaria Bancrofti*, he describes under the name of *Filaria sanguinis hominis* a mature worm, which was evidently the same parasite. Not unnaturally Dr Lewis put aside the nomenclature I had employed, on the ground that the name originally given by himself to the embryonal form ought to be retained, and that "a new name, if not necessary on anatomical grounds, would only lead to confusion."

Personally I have no objection to Lewis's specific name, but if the question of priority is to determine the nomenclature, then I fear we ought to call the species *Filaria Salisburyii.* Obviously the retention of Dr Salisbury's nomenclature (*Trichina cystica*) would be unsuitable and misleading.

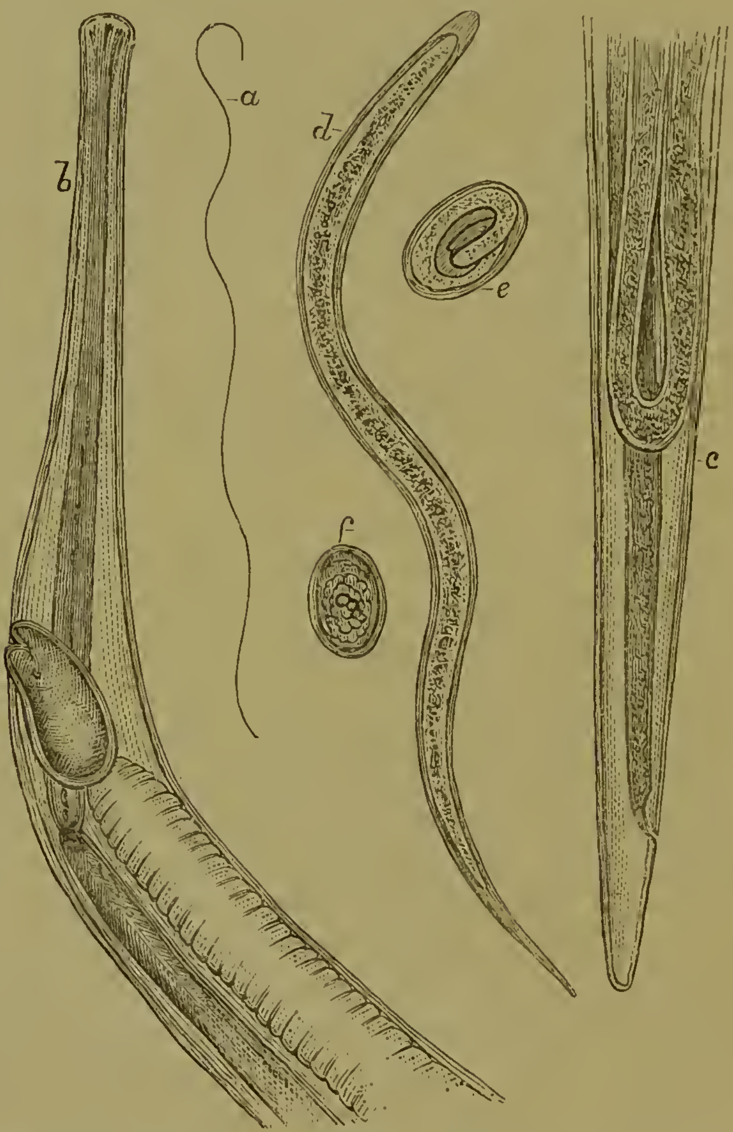

FIG. 39.—*Filaria Bancrofti.* *a*, Female (nat. size); *b*, head and neck (× 55 diam.); *c*, tail; *d*, free embryo (× 400 diam.); *e*, egg containing an embryo; *f*, egg, with mulberry cleavage of the yolk (× 360 diam.). Original.

When (prior to Lewis's discovery of the hæmatozoa) I had myself encountered larval nematodes of the same character as those described by Salisbury, I, like Wucherer, was careful not to employ a special name for an immature form, which might or might not represent a worm hitherto known to science. The paper in which I described the adult worm from specimens

supplied by Bancroft appeared in the 'Lancet,' Oct. 6th, 1877, the facts being stated as follows :—

On the 28th of August, 1877, I received a small collection of entozoa. The box contained the promised Filariæ, and also eight bottles filled with various intestinal worms taken from animals. The Filariæ were enclosed in four small tubes and preserved in glycerine. Three of the tubes (marked 1, 2, 3) contained sexually-mature worms, the fourth being labelled "Sediment from adult *Fil. sang.*—young and ova." I described their contents in succession. Thus, on the 6th of September, 1877, I examined the Filaria in tube No. 3. The specimen was injured and in four portions, these collectively measuring three inches in length. Although, to the naked eye, the worm had appeared to Dr Bancroft to be of the thickness of an ordinary human hair, yet I found it about $\frac{1}{90}''$ at the thickest part. It was a female. At the same time I examined the specimen in tube No. 1. This was also a female. Towards the centre of the body a hernial protrusion of the uterine horns and intestine had taken place. In a lithograph sent by Dr Bancroft this specimen was figured and described as the "parent worm of the *Filaria sanguinis*, emitting young Filaria from two loops." Later on I examined the contents of tube No. 2. In it I found one tolerably perfect female Filaria, and also a delicate shred forming part of one of the uterine horns of another worm. This filament measured one inch and a half in length, and was coiled round the complete worm. On transferring it to a watch-glass containing water, hundreds of embryos made their escape. Owing to the transparency of the tissues I had much difficulty in finding the reproductive outlet, and the effort to find it was all the greater because Bancroft's figure had misled me. At length I found the vagina and its orifice close to the head (about $\frac{1}{20}''$ from it), the anal orifice being placed within the $\frac{1}{90}''$ from the extremity of the tail. The vaginal pouch, $\frac{1}{100}''$ long, was crowded with embryos, and a constriction marked its junction with the uterus proper, which appeared to divide lower down at a distance of $\frac{1}{10}''$ from the head. Towards the tail a fold of the tuba Fallopii was seen to extend to within $\frac{1}{20}''$ of the extremity. All sections of the uterine system were crowded with germs, eggs, and embryos in their usual relative situations.

My examinations of the ova and embryos were chiefly made from the "sediment" sent in a special glass tube. The fully formed embryos were $\frac{1}{125}''$ in length by $\frac{1}{2500}''$ in breadth. They

each showed a double skin, the outer envelope in the more advanced specimens leaving clear spaces at either end of the body, resulting from commencing ecdysis. I saw no trace of intestinal tube, but a central line of condensation marked an early differentiation of the somatic granular contents. The less advanced embryos were mostly enclosed in a chorional envelope, the smallest free embryos measuring only $\frac{1}{200}''$ in length by $\frac{1}{3000}''$ in breadth. These had no double contour. The ova, whose yolk-contents were still in various stages of cleavage, gave an average long diameter of $\frac{1}{900}$ to $\frac{1}{1000}$ of an inch.

Such are the facts I made out, and they enabled me to amend the characters of the species.

As regards nomenclature, I associated Dr Bancroft's name with the sexually-mature worm as being in harmony with the binomial method and little calculated to mislead; moreover, it helped to fix both the source and date of the discovery (Brisbane, Dec. 21st, 1876). The use of this nomenclature detracts nothing from the high merits of Lewis, who first named the immature worm *Filaria sanguinis hominis.* As it now turns out, both Dr Salisbury and myself had previously been made acquainted with the young of *Filaria Bancrofti;* but it was reserved for Lewis to discover the hæmatozoal character of the embryos of this worm, and actually to take them from the blood. It was a singular circumstance, that when I was engaged in treating my little African patient for trematode hæmatozoa, it never once occurred to me that the numerous nematoid embryos mixed with the Bilharzia ova were hæmatozoal. As before remarked, it was alleged that my patient had passed worms two or three inches long by the urethra. I therefore concluded that these were the parents of the eggs and embryos, and that all of them were urinary. The inference was wrong, but it has instructively shown how near one may go towards a great discovery without really making it. As regards the larvæ, notwithstanding some slight differences in regard to size and so forth, I have little hesitation in saying that all the embryo forms severally described by Salisbury, by myself, by Lewis, Sonsino, Wucherer, Crévaux and Corre, Silva Lima, Bancroft, Manson, and others, are referable to one and the same species.

Into the clinical bearings of this subject it is impossible for me to enter at any length, but I may remark that these parasites appear to be associated with, if not actually the cause of,

several distinct morbid conditions. To one of these Bancroft has given a separate name (*Helminthoma elastica*). This is a highly elastic form of growth to which I have already alluded under the title of "lymphatic abscess of the arm." In the first valuable report on Hæmatozoa, by Dr Patrick Manson, of Amoy, China, this careful observer gives interesting particulars of no less than fifteen cases in which hæmatozoa were found. Two of these patients had *Elephantiasis scroti*, two had lymph-scrotum, two were lepers (one having scrotal disease), two had enlarged inguinal glands, one had anasarca; and of the remaining six, spoken of as having no concomitant disease, one had enlarged glands and abscesses, and another suffered from marked debility. It would thus appear that what is ordinarily termed "good health" is rarely associated with a hæmatozoal condition of the blood in the human subject. The cases given by Lewis and Manson, where absolutely no recognisable disease existed, must be regarded as exceptional. Disease, moreover, may exist without any palpable symptoms being exhibited by the "bearer," and thus perhaps it was with the hæmatozoal dogs of Gruby and Delafond to which I shall again have occasion to allude. Even those animals that carried upwards of two hundred thousand microscopic Filariæ in their blood appeared to suffer no inconvenience whatever.

In the autumn of 1877 Dr Da Silva Lima published an article in the 'Gazeta Medica da Bahia,' in which he dwelt upon the labors and merits of Wucherer, and, judging from an omission in one of my memoirs, he supposed that I had insufficiently acknowledged Wucherer's claims. A translation of this article appeared in the 'Archives de Médicine Navale,' with an important appendix by Dr le Roy de Méricourt. In this *addendum* the French *savant* showed that the omission on my part was unintentional, and had been corrected by me in a later memoir. Not only had I been amongst the earliest in England to enforce Wucherer's claims in respect of the micro-Filariæ, but I had first announced his discoveries in connection with *Anchylostoma duodenale*. In my translation of Wucherer's memoir ('Ueber die Anchylostomum Krankheit') I spoke of the melancholy satisfaction I had in knowing that the memoir in question was "among the last that appeared from the pen of that gifted and amiable physician." Some notice of Dr Lima's paper and its appendix by Dr A. le Roy de Méricourt appeared in the 'Lancet' for Jan. 5th, 1878, and I also published a full

translation of it, with explanatory notes, in the 'Veterinarian' for Feb., 1878. Later on, in the 'Lancet' (March 23rd, 1878), Dr Da Silva Lima published an interesting letter correcting a misconception that had incidentally arisen in the mind of a commentator (on the Helminthological work of 1877), and at the same time he pointed to the original facts connected with the discovery of Wucherer's Filaria. As my views are in perfect accord with those of Dr Da Silva Lima, I can only regret that errors of interpretation should have crept into the discussion. Dr Lima honorably recognises the nomenclature (*Filaria Bancrofti*) which I proposed for the adult worm, and only claims for Wucherer that which is fairly due.

On the 4th of January, 1878, I received from Dr Patrick Manson a manuscript in which he announced the discovery of the larvæ of *Filaria sanguinis hominis* in the stomach of mosquitoes. Already, in April, 1877, Dr Bancroft had informed me of his expectation of finding that these insects sucked up the larvæ of the Filaria whilst engaged in their attacks on man. Dr Bancroft's supposition was a very natural one, but it remained for Manson to make the actual discovery of the existence of human hæmatozoa, or parasites that had been such, within the stomach of *Culex mosquito*. I lost no time in making the principal facts public ('Lancet,' Jan. 12th, 1878). Dr Manson at the same time forwarded for publication a record of thirty-five additional cases of hæmatozoa occurring in Chinese subjects, together with additional particulars of one of the cases already published in the 'Customs Gazette.' These were afterwards published as separate contributions in the 'Medical Times and Gazette.' Dr Manson likewise forwarded materials for a paper entitled "Further Observations on *Filaria sanguinis hominis*." In this communication he gave an analysis of the cases (sixty-two in all) in which he had observed the hæmatozoa, and he added valuable statistical evidence as to the prevalence of Filariæ in the Amoy district, dwelling especially on the influence of age, sex, and occupation in determining the presence of the parasite. He also described the morbid states with which these entozoa were commonly associated.

On the 7th of March, 1878, I formally communicated to the Linnean Society a detailed account of Manson's investigations relating to the metamorphoses undergone by the Filariæ within the body of the mosquito. In this paper Manson pointed out

that the female mosquito, after gorging itself with human blood, repairs to stagnant water for the purpose of digesting the blood, and also for the purpose of depositing its eggs. During this period, which lasts four or five days, the Filariæ undergo remarkable changes. Subsequently, in a more perfect state, they escape into the water, and in this advanced stage they are conveyed to the human body along with the water as drink. Dr Manson persuaded a Chinese, whose blood was previously ascertained to abound with Filariæ, to sleep in a "mosquito house." In the morning the gorged insects were captured and examined under the microscope. A drop of blood from the mosquito was found to contain 120 Filariæ, but a drop taken from the man's hand yielded only some thirty specimens. Further stages of development are accomplished within the human host, ending in the sexual maturity of the parasite. After fecundation successive swarms of embryos are discharged by the female worm, a part of whose progeny eventually gains access to the blood.

Before I proceed to summarise the whole body of facts I must in the next place state that Manson and myself contributed a joint communication to the Medical Society of London on the 25th of March, 1878. In this memoir I especially dealt with the question of priority in connection with the discovery of the adult worm. I then restated that the adult parasite was discovered by Dr Bancroft on December 21st, 1876. The discovery was verified by Dr Lewis on August 7th, 1877, by Dr Silva Araujo October 16th, 1877, and by Dr F. dos Santos November 12th, 1877. I gave these dates unhesitatingly, without, however, in any way prejudicing the question already raised in respect of the identity of the worms found in each case. My own mind was fully made up on that point, and affirmatively so. Dr dos Santos' find was made in conjunction with Dr J. de Moura in a case of lymphatic abscess of the arm. Clinically viewed, the case published by Dr Araujo must be regarded as unique. Not only were adult and embryonic Filariæ found in the same patient, but, what was far more surprising and interesting, the patient displayed in his own person several of the disorders hitherto found apart; and he was more than once attacked by one or two of the diseases. He experienced a first attack of chyluria three years ago, then attacks of craw-craw commencing a year ago, the latter being attributed to bathing in a particular lagoon. He had a second

attack of chyluria six months back, at which time lymph-scrotum appeared, and also scrotal elephantiasis. Dr Bourel-Roncière pronounced this case to be unique, and attributed nearly all the disorders to the presence of Wucherer's embryonic Filariæ. In a very elaborate analysis of and commentary on Dr da Silva Lima's second memoir, Dr Bourel-Roncière warmly claims for Wucherer the supreme honor in all these discoveries. A number of affections hitherto regarded as distinct, and all of which appear to be due to the action of Filariæ, are regarded by Dr Bourel-Roncière as mere phases of one and the same disorder. This affection he terms *Wucherer's helminthiasis*. Dr Manson had indeed arrived independently at a similar conclusion, and I am confident that Wucherer, were he alive, would in this particular aspect of the question be the last to claim priority either to Lewis, to Bancroft, or to Manson.

In this place I may observe that Dr Pedro S. de Magalhães, of Rio de Janeiro, detected free microscopic nematodes in the potable waters of Rio (agua da Carioca), which from their similarity he supposes may have some genetic relation with *Filaria Bancrofti*. In this opinion I cannot share.

As regards the metamorphoses of the embryo, Manson states that for a little while after gaining access to the stomach of the mosquito the embryo undergoes no change (Fig. 40, *a*). In a very few hours changes commence, resulting in wider separation of the outer skin and an appearance of transverse markings on the body within (*b*). In the next stage oral movements occur; the striation becomes more marked, and the outer envelope is cast off (*c*). Then the striated lines disappear and a dotted appearance is substituted (*d*). From this condition the embryo passes to what Manson calls the chrysalis stage, in which nearly all movement is suspended and the large spots gradually disappear (*e*, *f*, *g*, *h*, *i*, *j*, *k*). The tail continues to be flexed and extended at intervals and the oral motions cease. By the close of the third day the embryo becomes much shorter and broader; but the finely pointed tail retains its original dimensions, projecting abruptly from the sausage-shaped body (*m*, *n*). Large cells next appear in the interior of the body, and by a little pressure one may detect indications of a mouth (*o*, *p*, *q*, *r*). At this period the embryo begins to elongate, and at the same time to diminish in width; but the growth takes place chiefly at the oral end of the body. The mouth becomes four-lipped,

FIG. 40.—Larval Filariæ in various stage of growth from the mosquito; *a* to *d*, representing the first stage of metamorphosis during the first 36 hours; *e* to *o*, the changes occurring during the second stage, to the close of the third day; *p* to *t*, forms seen during the third stage of metamorphosis from the fourth day onwards. The figs. *u*, *v*, represent the head and tail only, whilst *t* shows the young Filaria in an advanced stage, and drawn to a much smaller scale, than the others which are here magnified about 125 diameters. Much reduced from Manson's original figures.

open, and funnel-shaped, and from it a delicate line can be distinctly traced passing to an opening near the caudal extremity, the tail itself gradually disappearing (*s*, *t*). Speaking of the most advanced stage Manson says:—"A vessel of some sort is seen in the centre running nearly the whole length of the body and opening close to one extremity. This end is slightly tapered down and is crowned with three or perhaps four papillæ, but whether this is the head or tail, and whether the vessel opening near it is the alimentary canal or the vagina, I cannot say." Now it is quite evident, I think, from Manson's figures that he has here faithfully represented the head and tail, the former (*u*) to the left, the latter (*v*) to the right. In his *manuscript* (from which I am now quoting) there is no special reference to these two figures; but it is easy to see that these terminal sections of the body of the advanced embryo closely correspond with the head and tail of the adult worm (*Filaria Bancrofti*). The curved line passing to the left (*u*) evidently indicates the commencement of the partially-formed vagina.

How completely Manson took the initiative in this part of the work is evident even from Lewis's own later observations. In a paper published in March, 1878, Dr Lewis, writing from Calcutta and speaking of the rôle of the mosquitoes, says:—"I had repeatedly examined, in a cursory fashion, these and other suctorial insects, but had not observed any parasites suggestive of these embryo-hæmatozoa, hence, when, on receipt of a communication from Dr Manson a couple of months ago, a renewed search was made, I was surprised to find that four out of eight mosquitoes, captured at random in one of the servants' houses, harboured specimens of hæmatozoa to all appearances identical with those found in man in this country. After this, however, several days elapsed before any mosquitoes could be obtained which contained these embryo-nematoids, and the specimens obtained on the next occasion were devoid of the enveloping sheath, which appears to characterise the kind found in man out here, and apparently, according to Dr Manson, in China also." Further on Lewis also remarks, "When the insect is caught shortly after feeding and the contents of its stomach examined microscopically, the hæmatozoa, if present, will be observed to manifest very active movements, which may possibly continue for several hours on the slide. If the insect be kept for twenty-four hours before examination it is probable

that the movements of the parasites will be more sluggish, and their form probably altered owing to irregular contractions and dilatations of their substance—changes which may also occasionally be observed when embryo-hæmatozoa are preserved on a glass slide, and they may sometimes be kept alive thus, if in suitable media, for two or three days. When the insect is not examined till the third day, the contained parasites will probably manifest marked signs of disintegration—and possibly every indication of life will have disappeared from many of the specimens. After the third or fourth day I have not seen any active specimens of these entozoa in the stomach or in any part of the alimentary canal of the mosquito; those which remain have undergone more or less fatty degeneration, and are readily stained with eosin, which, as far as my experience goes, is not the case so long as they are alive and active. After the fourth or fifth day it is very rare that traces of any hæmatozoa-like objects can be detected at all, so that it must be inferred either that they have succumbed to the digestive action of the insect's stomach or been disposed of along with the excreta." An important *addendum* by Lewis records a fortunate incident as follows:—"It was observed that nearly all the mosquitoes captured in one of the servants' houses contained hæmatozoa, so that the supply of suitable insects in all the stages of their growth became amply sufficient for all requirements. The result of the examinations under these favorable conditions has shown that although the stomach digests a great number of the ingested hæmatozoa, as mentioned above, nevertheless others actually perforate the walls of the insect's stomach, pass out, and then undergo developmental stages in its thoracic and abdominal tissues."

I may here observe that Sonsino has instituted a comparison between the embryos of this Filaria and those of Anchylostoma, by which it appears that the former measure 0·218 to 0·330 mm. in length, and those of Anchylostoma 0·430 mm. The hæmatozoa are about forty times longer than broad, and the larval anchylostomes only fourteen times longer. The tail of *Filaria* is conspicuously longer.

In the 'Lancet' for June 22nd, 1878, an announcement appeared from the pen of Mr D. H. Gabb, of Hastings, stating that a patient under his care formed the habitat of *Filaria sanguinis hominis;* and in the autumn of the same year a paper which I read to the Linnean Society in the spring

was published. In that paper the following summary was offered:

1. *Filaria Bancrofti* is the sexually-mature state of certain microscopic worms hitherto obtained either directly or indirectly from human blood.

2. The minute hæmatozoa in question—hitherto described as Wucherer's Filariæ, *Filaria sanguinis hominis, Trichina cystica, Filariose dermathemaca,* and so forth—are frequently associated with the presence of certain more or less well-marked diseases of warm climates.

3. The diseases referred to include chyluria, intertropical endemic hæmaturia, varix, elephantiasis, lymph scrotum, and lymphoid affections generally, a growth called *helminthoma elastica,* a cutaneous disorder called craw-craw, and also leprosy.

4. It is extremely probable that a large proportion, or at least that certain varieties of these affections are due to morbid changes exclusively resulting from the presence of *Filaria Bancrofti* or its progeny within the human body.

5. It is certain that the microscopic hæmatozoa may be readily transferred to the stomach of blood-sucking insects, and it has been further demonstrated that the digestive organs of the mosquito form a suitable territory for the further growth and metamorphosis of the larval Filariæ.

6. The character of the changes undergone by the microscopic Filariæ, and the ultimate form assumed by the larvæ whilst still within the body of the intermediate host (*Culex mosquito*), are amply sufficient to establish the genetic relationship as between the embryonal *Filaria sanguinis hominis,* the stomachal Filariæ of the mosquito, and the sexually-mature *Filaria Bancrofti.*

In the month of September, 1878, I received a letter from Dr da Silva Lima announcing the fact that Dr Araujo had verified the existence of the embryos of *Filaria Bancrofti* in mosquitoes, at Bahia. These mosquitoes had, I understood, attacked a French priest in whose blood Dr Araujo also detected Filariæ. Thus, it fell to the lot of Araujo, through his untiring zeal, to verify in Brazil all the separate discoveries of Bancroft, Manson, and Lewis.

In the October issue of the 'Pathological Society's Transactions' for 1878 Dr Bancroft records numerous cases of filarious disease, and he gives a succinct account of the circumstances connected with his original discovery.

In a clinical lecture published October 12th, 1878, Dr Tilbury Fox seeks to diminish the value of these discoveries, characterising helminthological investigators as merely "recent writers." Dr Fox denies that Filariæ are a cause of true elephantiasis, but admits the occurrence of "elephantoid inflammation and inflammations due to Filariæ." Dr Fox's statement that "Filariæ have not been found in uncomplicated elephantiasis, that is, in disease without chylous exudation," seems to me to be directly at variance with Manson's recorded experiences. I hold that Manson has confirmed the truth of Lewis's views, and that he has thoroughly proved that (to use his own words) "varicose groin glands, lymph scrotum, elephantiasis, and chyluria are pathologically the same disease." In the first instance I was myself led to conclude that some of the forms of elephantiasis might be due to other causes than obstruction of the lymphatics caused by the presence of Filariæ; but the explanations of Lewis, of Bancroft, and of Manson more especially, have almost entirely removed this doubt. Those who seek to explain away the connection between genuine elephantiasis and Filariæ will do well to study Manson's last important memoir. He shows that "elephantiasis and allied diseases are much more frequently associated with the parasite than are other morbid conditions." This fact is brought out very clearly in his table of 670 cases, from which it appears that 58 per cent. of cases of Filaria are associated with elephantoid disease.

When this opposition to Manson's views is likely to cease (on the part of those who do not happen to have been in any way instrumental to the discoveries in question) it is not easy to say. In a brief communication which appeared in the last number of the 'Medical Times and Gazette' for 1878, Dr Manson successfully combats the doubts that have been entertained respecting the rôle of the mosquito. Because Lewis found that canine hæmatozoa were digested, and thus perished in the stomach of mosquitoes, it had been argued that *human* hæmatozoa must necessarily undergo similar processes, and consequently die. Those who oppose the views of helminthologists in respect of the intermediary host-function of insects on such grounds can have very little general, and still less special knowledge of the phenomena of parasitism. It is the old story. When any new discovery is made, it must always pass through the ordeals of denial and doubt before it can be gene-

rally accepted as true ; and, as in the case of Jenner's immortal discovery, there will always remain a certain number of peculiar people who show themselves hostile to every advance in science. Dr Manson may take comfort from this consideration, and rest assured that the value of his discovery is quite unaffected by the opposition referred to.

Since I communicated the results obtained by Manson, Lewis, myself, and others to the Linnean Society, an even more exhaustive summary of the facts has been published by Dr Bourel-Roncière, in the 'Archives de Médecine Navale.' The distinguished author does full justice to the writings of English helminthologists, and dwells, with emphasis, upon the finds and interpretations of Lewis, Manson, and Bancroft. Incidentally, also, he comments upon Sir Joseph Fayrer's early recognition of the etiological identity of hæmato-chyluria and elephantiasis, on other than helminthic grounds. The frequent concurrence of the two affections had especially struck Sir J. Fayrer as pointing to a probable common origin. He had also surmised that the disorders might be due to parasites.

Dr Bourel-Roncière, alike with the caution, precision, and logical reasoning of a cultured *savant*, concludes his elaborate review in the following terms :—"There are the facts. Certainly, many points remain obscure, many problems await a solution, and the last word has not been said on the actual part which the parasite plays in the pathogenesis of the affections above enumerated—its mode of action, the importance of its rôle, the extent of its pathological domain, the habitat of its progenitors, their identity, and so forth. All these questions will only be elucidated by necroscopic researches, which at present remain absolutely wanting."

"However, notwithstanding the doubts which hover over the future value of these curious discoveries, it is difficult not to recognise their importance in the study of certain tropical diseases—which up to the present time have been attributed to vague and undetermined causes—hæmato-chyluria and elephantoid affections principally. Apart from the interest which attaches to the natural history of the nematoids, they raise, in effect, etiological and prophylactic questions, the extreme importance of which we believe it would be needless to demonstrate. It is greatly to be desired that the researches should be taken up in other parts of the globe, where endemicity and perhaps greater facilities for necroscopic investigation would

render them fruitful—Cochin-China, Tahiti, &c. Fresh observations are necessary to confirm the first and to fill up notable gaps. The way has been brilliantly opened by the English and Brazilian physicians. Let our colleagues in the French colonies put their shoulders to the wheel; they have before them a vast field of study to explore."

Since the above remarks were written I have received several communications from Dr Bancroft, and also others from Drs da Silva Lima, Araujo, Assis Sousa, Paterson, Hall, of Bahia—the two last named being English physicians in practice there. I regret that I can do little more than refer to the writings of these authors in the Bibliography below; but I may observe that Drs Paterson and Hall have ascertained that the proportion of the population of Bahia affected by Filaria is $8\frac{1}{3}$ per cent. Out of 309 persons examined, 26 had hæmatozoa, which is, roughly, one in twelve, or more strictly, 8·666 per cent.

Amongst recent memoirs that by Sir J. Fayrer, read to the Epidemiological Society on the 5th of February, 1879, deserves especial attention. In regard to its significance, I have only space to remark that, much as we may regret the little interest shown by our hospital physicians and surgeons in this subject, it is particularly gratifying to see experienced Indian officers like Sir J. Fayrer, Mr Macnamara, and Dr John Murray, coming forward both to aid and render homage to their junior colleagues in Eastern parts, who are successfully labouring to advance the cause of helminthology and scientific medicine.

In concluding this subject I may observe, that one of the greatest hindrances to the due recognition of the remarkable part played by parasites in the production of human endemics and animal epizoötics arises from the circumstance that no inconsiderable number of minute worms may infest a host without obvious injury. This immunity proves nothing. If, for example, we take the case of *Trichina* we find that several millions of entozoa may exist in the human, or, at all events, in the animal bearer, without producing any symptom of discomfort. In such cases it is not possible to determine the strict limits of health and disease; nevertheless, were we to double the amount of infection, the imaginary line of demarcation is at once bridged over and the parasites become acknowledged as directly responsible for grave symptoms which may even prove fatal to the bearer. Again, the relative strength and size of the infected host constitute factors that materially limit the power of the

parasite for injury. Where the entozoa are of minute size, and where their injurious action is primarily due to the mechanical obstructions they set up, it is clear that the virulence of the helminthiases, or resulting diseased conditions, will mainly depend upon the number of intruders.

Another consideration of the highest value in relation to epidemiology generally, and more especially in regard to the practical question as to the best methods of stamping out parasitic plagues, is that which refers to the life-history of the entozoon itself. It must be obvious that in all cases where the intermediate host can be captured and destroyed, the life-cycle of the parasite can be broken and interrupted, and if thus broken, there is an end to the further propagation of the species. The knowledge that we have acquired by experimental research in this connection has already enabled us to set a limit upon the prevalence of certain well-known disorders, such as Trichinosis, Cestode-tuberculosis, and so forth. In the case of epizoötics, however, which are indirectly due to the action of intermediary hosts that cannot be readily captured or destroyed, then our power of arresting the disease is comparatively limited. In the present case it is probably not necessary either that a dead or living mosquito should be swallowed to insure infection; but it *is* necessary that the parasitic larvæ should have dwelt within the mosquito in order to arrive at the highest stage of larval growth prior to their re-entrance within the human territory. Undoubtedly, the larvæ are swallowed with potable waters. Perfect filtration before use would certainly check, if in course of time it did not totally extinguish several of the many virulent diseases that now afflict the inhabitants of warm climates.

It is with reluctance that I terminate this article, but in the closing pages of this work (Book II, Section V) I hope to add a few more particulars in reference to Lewis's latest researches.

Bibliography (No. 23).—*Araujo, A. J. P. da Silva,* "Memoria sobre a Filariose," &c., Bahia, 1875; see also 'Arch. de Méd. Nav.,' 1875 and 1878.—*Bancroft, J.,* "Cases of Filarious Disease," in 'Pathological Soc. Trans.' for 1878, vol. xxix, p. 407.—*Bourel-Roncière,* "*Résumé* of and Commentary upon the writings of Silva Lima, Silva Araujo, and others," in 'Arch. de Méd. Nav.' for March, 1878.—*Idem,* "Pathologie exotique. De l'hématozoaire nématoïde de l'homme et de son

importance pathogénique, d'après les travaux Anglais et Bréziliens des dernières années;" *ibid.*, for August and Sept., p. 113-134 and p. 192-214, 1878.—*Cobbold, T. S.*, "Discovery of the Adult Representative of Microscopic Filariæ," 'Lancet,' July, 1877, p. 70.—*Idem*, 'On *Filaria Bancrofti*,' *ibid.* Oct., 1877, p. 495.—*Idem*, "Verification of Hæmatozoal Discoveries in Australia and Egypt," 'Brit. Med. Journ.,' June, 1876.—*Idem*, "Obs. on Hæmatozoa," 'Veterinarian,' October, 1873.—*Idem*, "Remarks on the Ova of another Urinary Parasite (in the paper on 'Bilharzia') from Natal," 'Brit. Med. Journ.,' July 27th, 1872, p. 89; see also Bibl. No. 12.—*Idem*, "Entozoa in Relation to the Public Health" (various papers), 'Med. Times and Gaz.,' Jan. and Feb., 1871.—*Idem*, 'Worms' (l. c, p. 151), 1872.—*Idem*, "Hæmatozoa; Fresh Discoveries by Lewis," 'Lancet' for Feb. 6, 1875.—*Idem* (brief notice), the 'Veterinarian,' p. 209, March, 1875.—*Idem*, "On the Discovery of the Intermediary Host of *Filaria sanguinis hominis*," 'Lancet,' Jan. 12, 1878, p. 69.—*Idem*, "On the question of Priority of Discovery," Rep. of Med. Soc. of Lond., in 'Lancet,' March 30, 1878, p. 465.—*Idem*, 'Mosquitoes and Filariæ' (explanatory note), in 'Brit. Med. Journ.,' March 16, 1878, p. 366.—*Idem*, "On the Life-history of *Filaria Bancrofti*, as explained by the discoveries of Wucherer, Lewis, Bancroft, Manson, Sonsino, myself, and others," "Report of the Proceed. of the Linnean Soc." for March 7, 1878, in 'Pop. Science Rev.,' April, 1878; and afterwards published *in extenso* in 'Journal Linn. Soc.,' Oct. 31, 1878.—*Idem*, "On *Filaria Bancrofti*," in Part iv of a series of papers on the Parasites of Man, in the 'Midland Naturalist,' August, 1878.—*Idem*, "On *Filaria sanguinis hominis*," in a letter to the 'Lancet,' July 13, 1878, p. 64.—*Idem*, "Filariæ and Leprosy" (case from Bancroft); 'Lancet,' Feb. 1, 1879.—*Corré, A.*, "Note sur l'helminthe rencontré dans les urines hémato-chyleuses," 'Rev. des Sci. Nat.,' 1872.—*Cossé*, "Sur l'helminthe rencontré par Wucherer et Crevaux," &c., 'Rev. Montpellier,' tom. i, p. 190.—*Couto, A.*, "These de concourso," Bahia, 1872.—*Crevaux, J.*, 'De l'hématurie chyleuse, &c.," 1872; also in L'Union Médicale,' 1872 (abs. in 'Brit. Med. Journ.,' July, 1872, p. 100); also in 'Arch. de Méd. Nav.,' 1874; and in 'Journ. de l'Anat. et de la Physiol.,' 1875 (see also Silva Lima).—*Davaine, C.*, 'Traité,' 2nd edit., p. 944; 'Hæmatozoaires,' supp., 1877.—*Fayrer, Sir J.*, "Filaria sang. hom.," 'Lancet,' March 16, 1878, p. 376.—*Idem*, "Elephan-

tiasis Arabum," 'Med. Times and Gaz.,' Dec. 1, 1877, p. 588; "On the Relation of *Filaria sanguinis hominis* to the Endemic Diseases of India," in the 'Lancet,' Feb. 8 and 15, and reprinted from the 'Med. Times and Gazette' (same date), 1879.—*Gabb, D. H.*, letter in 'Lancet,' June 22, 1878.—*Leuckart*, l. c., s. 638, 1876.—*Lewis, T. K.*, "On a Hæmatozoon in Human Blood," 'San. Comm. 8th Rep.,' Calcutta, 1872; 'Med. Press,' 1873, p. 234; 'Indian Ann. Med. Sci.,' 1874; 'Lond. Med. Rec.' (abs. by myself in vol. i, p. 5), 1873.—*Idem*, "Pathological Significance of Nematode Hæmatozoa," 'Tenth Ann. Rep.,' 1873, Calcutta (reprint), 1874; 'Ind. Ann.,' 1875.—*Idem*, "Remarks regarding the Hæmatozoa found in the Stomach of *Culex mosquito*," 'Proc. Asiatic Soc. of Bengal,' March, 1878, p. 89.—*Idem*, "Flagellated Organisms in the Blood of Rats" (being portion of a paper on "The Microscopic Organisms found in the Blood of Man and Animals," in '14th Annual Report of the San. Comm. with the Govt. of India'), in the 'Quart. Journ. of Micr. Science,' Jan., 1879.—*Idem* (published since the present article was written), "The Nematoid Hæmatozoa of Man," *ibid.*, April, 1879.—*Lima, J. F. da Silva* (with *Crevaux*), 'Memoria sobre hematuria chylosa ou gordurosa des paizes quentes;' extrahida da 'Gazeta Medicà da Bahia,' 1876; repr. in 'Arch. de Méd. Nav.,' Dec., 1878 (see also Le Roy de Méricourt).—*Magalhães, Pedro S. de*, "Filarias em estado Embryonario, encontradas n'agua tida como potavel (agua da Carioca)," 'O Progresso Medico,' Dezembro, 1877, p. 57.—*Idem*, "Nota sobre os nematoides encontrados no sedimento deposito pela agua (potavel) da Carioca," 'O Prog. Med.,' 1 de Setemb., 1878, p. 577.—*Idem*, "Caso de filariose de Wucherer;' *ibid.*, 15 de Setemb., 1878, p. 589.—*Makina, M.D.*, "Filaria in Chyluria," letter in 'Lancet,' Feb. 22, 1879, p. 286.—*Manson, P.*, "Rep. on Hæmatozoa," 'Customs Gazette,' No. 33, Jan.–March, 1877; see also 'Med. Times and Gaz.' for Nov. 10, p. 513, Nov. 17, p. 538, and Nov. 24, p. 563; Dec. 1, p. 589, 1877; also Jan., 1878.—*Idem*, "Additional Cases;" *ibid.*, March 2, 9, 23, 1878.—*Idem*, "On *Filaria sanguinis hominis*, and on the Mosquito considered as a Nurse," 'Proc. Linn. Soc.,' March 7, 1878; see also report in 'Nature,' March 28, 1878, p. 439.—*Idem*, "On *Filaria sanguinis hominis*, clinically considered in reference to Elephantiasis, Chyluria, and allied Diseases," 'Rep. of Med. Soc. of Lond.,' in 'Lancet,' March 30, 1878.—*Idem*, "Further Observations on *Filaria sanguinis hominis*," "Med.

Rep." for April—Sept., 1877, in 'Customs Gazette,' Shanghae, 1878.—*Idem*, "The Development of the *Filaria sanguinis hominis*," 'Med. Times and Gaz.' for Dec. 28, 1878, p. 731.—*Méricourt, A. Le Roy de*, in Appendix to an art. entitled "Nouvelle phase de la question relative à la nature parasitaire de la chylurie. Découverte du représentant adulte de la 'Filaire de Wucherer,'" par le Dr da Silva Lima, from the 'Gaz. Med. da Bahia,' Sept., 1877; see also the 'Lancet,' Jan., 1878, p. 22 (editorial notice).—*Moura, J. de*, 'These de Concourso,' 1877.—*O'Neill*, "On Craw-craw," 'Lancet,' Feb., 1875.—*Pareira, A. P.*, "On Bilharzia and Chyluria," 'Gazeta Med. da Bahia,' No. 9, 1877 (noticed in 'Lancet,' Feb. 2, 1878).—*Salisbury, J. H.*, "On the Parasitic forms developed in Parent Epithelial Cells of the Urinary and Genital Organs," 'Hay's American Journ.,' vol. iv, 1868, p. 376.—*Santos, F. dos*, in 'Gaz. Med. da Bahia,' March, 1877.—*Sonsino, P.*, 'Richerche,' &c., 1874; 'Della Bilharzia,' &c., 1876; 'Sugla Ematozoi,' &c., 1876 (see Bibl. No. 12).—*Idem*, "On the Diagnosis of Embryos of Filaria," in his paper 'Sull' Anchylostoma duodenale;' 'Estr. dall Imparziale,' 1878.—*Sousa, M. de A.*, 'Memoria sobre a Elephantiasis do escroto,' Bahia, 1878.—*Wucherer, O.*, "Noticia Preliminar," &c., 'Gaz. Med. da Bahia,' Dec., 1868.—*Idem*, 'Sobre Hematuria no Brazil,' *ibid.*, Sept., 1869; see also "Méricourt's trans. (De l'hématurie intertropicale observée au Brézil)," 'Arch. de Méd. Nav.,' p. 141, 1870, and the fuller references quoted in my memoir; 'Linn. Soc. Journ., Zool.,' vol. xiv, p. 368.

Filaria Loa, Guyot.—Although further examinations of this worm will probably result in placing it in some other genus than *Filaria*, yet it is by no means clear that Diesing was right in placing it with the genus *Dracunculus*. I therefore abandon the nomenclature adopted in my previous treatise. According to the surgeon, Guyot, who made seven separate voyages to the coast of Angola, these worms cannot be confounded with the Dracunculus. They are quite white, and relatively much thicker than guinea-worms. Under the title of *Filaria oculi* Moquin-Tandon has spoken of certain small nematodes as "not uncommon in the negroes of the Angola coast;" and he gives other localities where it occurs. The worms are identical with those described by Guyot as dwelling beneath the conjunctivæ of negroes at Congo and in the Gaboon region generally. The parasite is rather more than an inch and a quarter in length, being pointed at one end and blunt at the other. It is termed

Loa by the natives, who state that after a period of several years the worm voluntarily quits the organ. The disease is thus naturally cured. This parasite enjoys a tolerably wide geographical distribution, as it has been observed by Clot Bey in a negress who had come from the town of Monpox, situated on the banks of the River Magdalena; by Sigaud, who saw one in the eye of a negress in Brazil; by Blot, at Martinique, who saw two in a negress originally from Guinea; by Bajon, who met with one in a little negro girl who had come from Guadeloupe; by Mongin, who found one in a negress who had been living in the Island of San Domingo; and by Lestrille, who removed one from beneath the conjunctiva of a negro who came from Gaboon.

Bibliography (No. 24).—*Davaine,* l. c., p. 839.—*Guyon,* 'Gaz. Méd. de Paris,' p. 106, 1841, and in 'Micr. Journ. and Struct. Record,' p. 40, 1842, and in 'Dublin Journ.,' vol. xxv, p. 455, 1839.—*Idem,* 'Compt. Rendus,' tom. lix, p. 743, 1865.—*Guyot,* in 'Mém. par Arrachait,' p. 228, 1805.—*Küchenmeister,* l. c., s. 322.—*Lestrille,* in Gervais and Van Beneden's 'Zool. Med.,' 1859, also quoted by Davaine, l. c., 2nd edit., p. 840.—*Leuckart,* l. c., s. 619.—*Moquin-Tandon, A.,* 'Zool. Med.,' Hulme's edit., p. 363, 1861.

Filaria lentis, Diesing.—This is a doubtful species. The worm was first discovered by Nordmann, in a case of lenticular cataract under the care of Von Gräfe, and it was afterwards found by Jüngken in a similar case, as recorded by Sichel. There is also the instance described by Gescheidt, in which Von Ammon operated, and from which brief descriptions of the worm have generally been taken. In this case there were three worms, two measuring about $\frac{1}{6}''$ and the third $\frac{1}{15}''$ in length. In Jüngken's case (exhibited by Quadri, of Naples, at Brussels) the worm was more than $\frac{3}{4}''$ long. In another case, reported by M. Fano, the worm was somewhat less than $\frac{1}{4}''$ long. There is no certain evidence that any of these various worms had developed sexual organs in their interior. It is true that the reproductive organs were described in two of the worms observed by Gescheidt; but after a due consideration of all the facts I fear we must conclude that all the worms in question were sexually-immature and wandering nematodes, possibly referable to Gurlt's *Filaria lacrymalis,* as Küchenmeister long ago suggested.

Bibliography (No. 25).—*Cobbold,* 'Entozoa,' p. 332.—*Da-*

vaine, l. c., p. 821 *et seq.*—*Diesing*, 'Syst. Helm.,' p. 625.—*Fano*, 'Traité des Malad. des Yeux,' tom. ii, p. 498; and in 'Rec. de Méd. Vét.,' p. 140, 1869; quoted by Davaine, p. 831.—*Gescheidt*, Ammon's 'Zeitsch.,' 1833, s. 435.—*Leuckart*, l. c., Bd. ii, s. 622.—*Nordmann*, l. c., Bibl. No. 2, s. 7, 1832.—*Sichel*, 'Iconogr. Ophth.,' p. 707, 1859.

Filaria labialis, Pane.—This is a filiform cylindrical worm measuring an inch and a quarter in length. The mouth is armed with four papillæ arranged in the form of a cross. The tail of the female is blunt, the vaginal outlet being placed at a very short distance from its extremity, and a little above or in front of the anus. This parasite was found by a medical student at Naples. It occupied the cavity of a pustule in the upper lip, giving rise to considerable irritation. Only the male worm is at present known.

BIBLIOGRAPHY (No. 26).—*Davaine*, l. c., edit. ii, Synopsis, p. 107.—*Leuckart*, l. c. (with a fig.), Bd. ii, s. 616.—*Pane*, "Nota di un elminte nematoide," in 'Annali dell' Acad. degli aspiranti Naturalisti,' Napoli, ser. 3, vol. iv, 1864.

Filaria hominis oris, Leidy.—In the fifth volume of the 'Proceedings of the Philadelphia Academy of Natural Sciences' (1850, p. 117) Dr Leidy furnishes the following description of this worm as gathered from the examination of a simple specimen preserved in alcohol, and labelled as having been "obtained from the mouth of a child." Body white, opaque, thread-like; mouth round, simple; posterior extremity obtuse, furnished with a short, curved, epidermal hooklet, $\frac{1}{500}''$ in length, by $\frac{1}{2000}''$ in diameter at base. Dr Leidy offers some speculations as to its origin, but from whatever source the worm was obtained by the bearer, it seems to be an immature form. Its length is five inches and seven lines.

Filaria (*Nematoideum*) *trachealis*, Bristowe and Rainey.—This is another very doubtful worm. It was originally described in the 'Pathological Society's Transactions' for 1855. It evidently represents only a juvenile stage of growth of some species of round worm. Rainey discovered a considerable number of these worms in the trachea and larynx of a person who died from a disease affecting the lower extremities. Individually the parasites measured about the $\frac{1}{50}''$ in length.

Strongylus (*Filaria*) *bronchialis*, Rudolphi.—This is a small nematode. The male measures rather more than half an inch, whilst the female is upwards of an inch in length. The caudal

appendage of the male is furnished with a bilobed, membranous, half-bell-shaped bursa. This surrounds the cloacal outlet, the latter concealing a double spiculum. The tail of the female is sharply pointed, the anal orifice being placed a little in front or above. The body is filiform, of a pale yellow color. It is about $\frac{1}{50}''$ broad in the male, and $\frac{1}{35}''$ in the female. The mode of reproduction is viviparous.

The original specimens were discovered by Treutler in Germany, during the winter of 1791, in the bronchial glands of an emaciated subject, whilst those sent to Diesing for description were discovered by Dr Fortsitz at Klausenberg, in Transylvania, in the lungs of a boy six years old. Diesing and Weinland suggested the identity of *Filaria bronchialis* and *Strongylus longevaginatus*, whilst Küchenmeister went further, and pronounced them to be one and the same species.

Bibliography (No. 27).—*Cobbold*, 'Entoz.,' p. 357.—*Davaine*, 'Synops.,' l. c., 'Synopsis' cix.—*Küchenmeister*, l. c., Eng. edit., p. 381.—*Leuckart*, l. c., s. 618.—*Treutler, F. A.*, "De vermibus filiformibus (*Hamularia lymphatica*) in glandulis conglobatis bronchiorum repertis," in 'Obs. Pathol. Anat.,' 1793.—*Wedl.*, 'Die im Menschen vorkommenden Helminthen' (quoted by Leuckart), Wien, 1862, s. 22.

Eustrongylus gigas, Diesing.—This is by far the largest nematode known to science, the male sometimes measuring a foot in length and the female more than three feet, whilst the breadth of the body reaches half an inch at the thickest part. Though fortunately very rare in man, this worm is known to occur in a great variety of animals, especially in weasels. According to Weinland and Jackson, it is particularly abundant in the kidney of the North American mink (*Mustela vison*), destroying the substance of the organ, the walls of which become the seat of calcareous deposit. It has been found in the dog, wolf, puma, glutton, raccoon, coati, otter, seal, ox, and horse.

The body of the adult worm is cylindrical, more or less red in color, and somewhat thicker behind than in front. The head is broadly obtuse, the mouth being supplied with six small, wart-like papillæ, two of which correspond with the commencement of the two lateral lines of the body. These lines are also distinguishable from other six longitudinal lines traversing the body from end to end by the presence of very minute papillæ which are less closely arranged towards the

centre (Leuckart). The tail of the male shows a simple, thick, cup-shaped bursa, which is destitute of rays, and partly conceals the simple spiculum. The tail of the female is blunt and pierced by the centrally placed anal opening. The vulva is situated near the head in the ventral line. The eggs are stout and oval, measuring $\frac{1}{300}''$ in length by about $\frac{1}{350}''$ in breadth.

As regards development the recent researches of Schneider have shown that certain kinds of fish play the part of intermediary bearer. Balbiani preserved the ova in water for more than a year without their hatching, and all his attempts to rear the larvæ in the intestines of the dog by direct experiment failed. Similar feeding experiments upon fishes and reptiles also failed. The embryo, when removed from the egg, measures $\frac{1}{104}''$ in length. It is vermiform, having a pointed head and simple mouth. Balbiani describes the buccal cavity as containing a protractile stylet. Notwithstanding the negative results obtained by Balbiani's experiments on fishes, Schneider (from anatomical data, which Leuckart confirms) has placed it almost beyond question that the worm hitherto known as *Filaria cystica* is the sexually-immature *Eustrongylus gigas*. This worm is found encysted beneath the peritoneal membrane in *Galaxias scriba* and *Synbranchus laticaudatus*. It is worthy of remark that the genus Galaxias comes nearer to the Salmonidæ than to the pike family, whilst the Synbranchi are tropical oceanic fishes. Probably the sexually-immature worm occurs in other fishes, especially the Salmonidæ.

Remarkably fine examples of the adult worm may be seen in the Hunterian Collection, Lincoln's Inn, and in the Museum of the Royal Veterinary College. The human example is undoubtedly genuine. The dissections in the Hunterian Collection of specimens were made by me in 1865. Objection has been taken to my description of the œsophagus as "spiral." In Sheldon's specimen it is certainly twisted upon itself, precisely in the manner in which Davaine has also figured it ('Traité,' fig. 68); but I cannot here give further anatomical particulars. Drelincourt found two worms sexually united in the kidney. When once the parasites have gained access to this organ, rapid destruction of the glandular substance follows. Ultimately the kidney is reduced to the condition of a mere cyst or bag, which, besides the worms, contains a quantity of sanguino-purulent matter. Frequently only one worm is present, but

oftener two or three. In the kidney of a puma D'Azara's friend, Noseda, found no less than six worms, whilst Klein obtained eight from the kidney of a wolf.

BIBLIOGRAPHY (No. 28).—*Azara, F. de,* 'The Natural History of the Quadrupeds of Paraguay,' trans. from the Spanish by W. P. Hunter ; Valpy's edit., p. 43, 1837 ; Black's, 1838 ; French edit., p. 313, 1801.—*Albers,* 'Beitr. z. Anat. &c.,' Bd. i, s. 115.—*Aubinais,* 'Revue Méd.,' 1846, p. 284.—*Balbiani,* "Recherches," &c., 'Compt. Rend.,' 1869, p. 1091 ; 'Rec. de Méd Vét.,' 1870, p. 5.—*Bickford,* "Spec. of *Str. gigas* found in the Kidney of a Dog," the 'Veterinarian,' 1859, p. 312.—*Blainville,* 'Dict. des Sci. Nat.,' tab. 29.—*Blanchard,* 'Ann. des Sci. Nat.,' 1849, p. 186.—*Idem,* in 'Cuvier's Règne Animal' (Masson's edit.), 'Les Intestinaux,' p. 57, pl. 27.—*Blasius,* 'Obs., &c.' (with fig. of Lumbricus in renibus hominis), 1674, p. 125.—*Bobe-Moreau,* in 'Journ. de Méd.,' tom. xlvii.—*Boerhaave,* 'Aphorism.,' 1728.—*Bremser* (l. c., Bibl. 2), s. 223.—*Chabert,* 'Traité des maladies verm. dans les Animaux,' 1782.—*Chiaje,* 'Comp. d. Elmintogr. umana,' p. 106.—*Clamorgan, J. de,* 'La Chasse de Loup,' 1583 (quoted by Davaine, the worms being described as "serpents et bêtes fort venemeuses").—*Cobbold,* 'Entoz.,' p. 358.—*Idem,* 'Catalogue of Entozoa in the Museum of the Roy. Coll. of Surg.,' "Descr. of preps. Nos. 19—25," p. 3, 1866.—*Idem,* "Parasites of Man," 'Midland Naturalist,' Dec., 1878.—*Collet-Meygret,* "Mém. sur un ver trouvé dans le rein d'un Chien," in 'Journ. de Physique,' &c., 1802.—*Cuvier,* see *Blanchard* (supra).—*Idem,* 'Voyage en Sicile,' and in 'Ann. des Sci. Nat.,' tom. xi.—*Davaine, C.,* 'Traité,' l. c., deuxième edit., p. 271 *et seq.* (with full lit. refs. at p. 290).—*Diesing,* l. c., vol. ii, p. 325.—*Dujardin,* l. c., p. 113.—*Frank, F.,* "Ein Spulwürm in der Urinblase eines Hundes," 'Hufeland's Journ.,' Bd. xviii, s. 112.—*Jackson,* 'Catalogue of the Boston Museum,' 1847, p. 317.—*Klein, T. K.,* "Anatomical Description of Worms found in the Kidneys of Wolves," 'Phil. Trans.,' 1729-30, p. 269.—*Küchenmeister,* l. c., Eng. edit., p. 376.—*Leblanc* (rep. by Rayer and Bouley), in 'Bull. de l'Acad. de Méd.,' 1850, p. 640 ; in 'Rec. de Méd. Vét.,' 1862, p. 800 ; and quoted by Davaine.—*Leuckart,* l. c., Bd. ii, s. 353-401, 1876.—*Moublet,* "Mém. sur les vers sortis des reins et de l'urethre d'un enfant," 'Journ. de Méd-Chir. et Pharm.,' 1758, pp. 244 and 337.—*Otto* (Anat.), in 'Mag. d. Gesellsch. naturf.,' 1814.—*Owen,* art. "Entozoa," in Todd's 'Cyclop.'—*Rayer,* 'Traité des maladies

des reins, 1841.—*Rayger*, 'Sur un serpent qui sortit du corps d'un homme après sa mort' (quoted by Davaine, l. c., p. 272), 1675. — *Schneider*, 'Monographie der Nematoden,' 1866, s. 50.—*Idem* (mit Peters), quoted by Leuckart, l. c., s. 382.—*Stratton*, in 'Edin. Med. and Surg. Journ.,' p. 261, 1843.

Dochmius duodenalis, Leuckart.—Much time might be occupied and wasted over the nomenclature of this parasite. In my previous treatise, and for reasons there stated, I placed it under the genus *Sclerostoma*. On rather slender grounds Dubini formed the genus *Anchylostoma* for its reception, but Von Siebold thought that, on account of the absence of symmetry in the arrangement of the so-called dental organs, Dubini's genus might very well be allowed to remain. Bilharz, Diesing, Küchenmeister, Wucherer, and others have retained the genus as either *Ancylostoma* or *Anchylostomum*. Schneider keeps it amongst the *Strongyli;* but after all that has been said and written there can, I think, be no doubt that if Dujardin's genus *Dochmius* is to be retained at all, Dubini's worm must be placed in it. The comparisons instituted by Leuckart afford sufficient proof of the intimate alliance as between *Anchylostoma* and *Dochmius*. Professor Molin thought to meet the difficulty by calling the worm *Dochmius anchylostomum*, but the specific term, *duodenale*, should certainly be retained.

This worm was discovered by Dubini at Milan, and though at first thought rare, it is now known to be tolerably common throughout Northern Italy. The worm has also been recently found by Dr Kundrata at Vienna, in an Austrian subject. According to Pruner, Bilharz, and Griesinger, it is abundant in Egypt. Griesinger believed that about one fourth of the people of that country suffered from anæmic chlorosis, solely in consequence of the presence of this worm in the small intestines. From Wucherer's observations especially, we know that Dubini's worm is not limited to the localities above mentioned, for it occurs in the western tropics, in Brazil, and even in the Comoro Islands.

The worm may be described as a small nematode, the males measuring $\frac{3}{8}''$ or rather more, whilst the females extend to very nearly $\frac{1}{2}''$ (12 mm.). The head is pointed and tapering, and bent forward, having the mouth directed towards the ventral aspect. The oral opening is armed with four asym-

metrically disposed, unequally-sized, horny, conical, converging teeth. The neck is continuous with the cylindrical body, which is $\frac{1}{80}''$ in thickness. The body terminates in a straight cone-shaped, or rather sharply-pointed tail in the female, the caudal extremity of the male ending in a partially inflexed, blunt point. In the male there is a cup-shaped, bilobed bursa, the membranes of which are supported by eleven chitinous rays, ten being simple, whilst the median, or odd one, is bifurcated at the summit. The mode of reproduction is viviparous. Adult males and females occur in the proportion of one of the former to three of the latter.

FIG. 41.—Male *Dochmius duodenalis*, with bursa separately enlarged. After Küchenmeister.

As above mentioned, it was Griesinger who first pointed out the clinical importance of this entozoon. He first explained the manner in which the worm produces anæmia, the persons attacked losing blood as if they were being bitten by innumerable small leeches. Like the rest of their kindred, these worms are veritable blood-suckers. In the first instance the views of Griesinger met with opposition, but they have since received abundant confirmation. Whilst Küchenmeister's 'Manual' furnishes an excellent account of the disorder as known in Europe, we are chiefly indebted to Wucherer for what is known of the disorder in Brazil. The experiences recorded in the 'Deutsches Archiv für Klinische Medicin' for Sept. 27th, 1872 (s. 379-400), were amongst the last that appeared from the pen of that gifted and amiable physician. As little or no notice of his writings appears to have been taken by professional men in this country, I depart somewhat from the design of this work when I venture to abstract a few of the clinical particulars which he has supplied. Their importance in relation to sanitary science is obvious, inasmuch as these parasites are introduced into the human body by drinking impure water, or, at least, water which either contains the free larvæ of the worm, or the intermediary bearers that harbor the larvæ.

It should be borne in mind that Dubini's original discovery was made at Milan in 1838, whilst Griesinger's recognition

of the worm as a cause of the Egyptian chlorosis resulted from a post-mortem examination made on the 17th of April, 1851.

In the journal above mentioned, Wucherer records his own discoveries as follows (‘Ueber die Anchylostomunkrankheit,’ &c.) :—“ Although Griesinger with well-founded confidence gave an account of his ‘ find ’ and its significance, yet it remained for a long time unnoticed and unutilised, till at length a case led me to corroborate it. During my many years’ residence in Brazil, especially during the first year, I had very frequent opportunities for witnessing the tropical chlorosis, but seldom to treat it, as it is one of those diseases for which Brazilians seek no medical assistance. Its treatment falls to the lot of the *curiosos, curadeiros* (quacks), who employ the fresh pulp of a species of fig as a remedial agent with the best results. On the 13th of December, 1865, I was called to the Benedictine monastery in Bahia to see a slave of the *order* suffering from *hypoœmia.* The patient was about thirty years of age, married, a strongly built mulatto. He was a field laborer on the Ingua plantation of the order, who exhibited in a conspicuous degree all the symptoms that occur in hypoæmia except the diarrhœa. He was well nourished, but strikingly pale, his whole face, but especially the eyelids, being œdematously swollen, as also were the feet, legs, and hands. The hands and feet were very cold. His appearance betrayed the most horrible anguish or low despondency. With difficulty only could he raise himself, being obliged to lie down again immediately on account of his weakness. Auscultation revealed a diminished respiratory murmur, and bronchial expiration in both lungs. The pulse was very rapid and small, the patient complaining of pain in the region of the heart. He had frequent palpitation when he moved, and he complained of pain in other parts of the body. His abdomen was much distended by gases, but not sensitive to pressure from without, except in the region of the stomach. The urine was clear, its specific gravity 1007 to $1023\frac{1}{2}°$. Under great difficulties he resided for several months after his marriage at Inhatâ. Earlier he had been on the estates of the order at Rio de S. Francisco. He there suffered for a long time from intermittent fever, but at Inhatâ he entirely recovered. At Inhatâ the slaves frequently suffered from hypoæmia, but in S. Francisco not at all. He appears not to have made any misuse of brandy. The slaves of the order were well cared for,

and supplied with good and wholesome nourishing food. The patient had already, for a long period, treated himself with steel wine, yet was continually getting worse and worse. He had not taken the pulp of the fig. As I was unaware he had suddenly become so ill, they hastily despatched a message to the town. There was no good to be expected from the further employment of iron, and the patient was in such a condition that from the very first I despaired of his recovery. I immediately prescribed the pulp of the Gammeleira (*Ficus doliaria*), but it could not be easily obtained. Considering that the Gammeleira would have a drastic effect, I therefore prescribed two grammes of elaterium, to be divided into eight doses, of which he should take one every three hours." Dissatisfied with this advice, however, Dr Wucherer goes on to say that on reaching home he carefully looked up the literature of the subject. "In a 'Geologico-Medical Report' by Professor Hirch, recorded in the ninety-sixth volume of 'Schmidt's Jahrbucher,' I found how Griesinger had recognised the *Anchylostoma* as the cause of the Egyptian chlorosis, which was clearly identical with our *hypoœmia*. He had employed this commended anthelmintic. I resolved the more to prescribe the pulp of the Gammeleira when I found it described as a worm-expelling remedy in Martin's 'Systema Materiæ Vegetabilis Braziliensis.' The next morning, however, when I arrived at the monastery I learnt that my patient died about two hours after a slight evacuation. Only after much resistance would they permit the *sectio cadaveris*. I merely opened the abdomen, and was surprised to find everything as Griesinger had described. During the next season, through the courtesy of my colleagues attached to the General Infirmary at Bahia, especially of Drs Silva Lima, Faria, and Caldos, I was enabled to open more than twenty bodies of anæmically deceased individuals. All were selected as miserably poor in condition, but only five were bodies of persons in whom hypoæmia was diagnosed, and in these there were a great number of Anchylostomes in the small intestine. The intestines of the other bodies contained either none, one, or a few." Dr Wucherer next states that he compared the characters presented by his entozoa with those given by Dubini, Diesing, and Von Siebold, and found a perfect agreement throughout. He sent several examples to Griesinger, who also established their identity, and communicated the results of his investigations accordingly ('Archiv für Heilkunde,' 1866, s. 387.

See also Leuckart, 'Die Mensch. Par.,' Bd ii, s. 411). Dr Wucherer also forwarded a number of specimens to Dr Weber, who published a brief account of them with excellent figures ('Path. Soc. Trans.,' vol. xviii, 1867, p. 274). As mentioned in the text of his memoir (s. 394), Dr Wucherer also transmitted some strongyloids to myself. "The publication of my observations," adds Dr Wucherer ('Gazeta Medica da Bahia,' 1866, p. 27 *et seq.*), "had a result in that Dr J. R. de Moura, of Thersepolis, in the province of Rio de Janeiro, sought for Anchylostomes in the bodies of tropical anæmics (*Hypöæmikern*). He at once found these parasites, as stated in the same journal (for 1866, p. 132). As occurred to myself, he saw no enduring results from the application of the remedies which appeared to be called for, whilst he well knew that unprofessional persons (Nichtärzte) succeeded in obtaining marked results by the exhibition of the pulp of the Gammeleira (*Ficus doliaria*). The anthelmintic action of this remedy was also unknown to him." Dr. Wucherer then records how his discovery of these entozoa was announced by Dr Jobini to the Rio academy, and how Dr Moura's observations were subsequently communicated, adding remarks upon the interesting discussion that followed. The general opinion was that the *Anchylostomata* were *not* the primary and necessary cause of this tropical anæmia, but rather a co-operating agent in its production. Against this view Dr Wucherer afterwards very properly protested ('Gazeta,' Jan. 15th, 1868). In the mean time, says our author, "Dr le Roy de Méricourt, prompted by my first communication, had invited the physicians of the French colony to seek for Anchylostomes. Drs Monestier and Grenet, at Mayotta (one of the Comoro Isles, which lies about 12° S. lat. to the north-east of Madagascar), ascertained the presence of entozoa in hypoæmics. Dr Grenet sent the duodenum and a portion of the jejunum of an hypoæmic corpse to Le Roy de Méricourt, who compared the Anchylostomes with Davaine's description, and recognised them as examples of *A. duodenale.*"

"In the year 1868 Dr Rion Kérangel found Anchylostomes in the bodies of hypoæmics in Cayenne. Thus, the occurrence of Anchylostomes in hypoæmics has been authenticated by Pruner, Bilharz, and Griesinger, in Egypt; by myself, Dr Moura, Dr Tourinho, and other physicians, in Brazil; by Monestier and Grenet, in the Comoros; and by Rion Kérangel in Cayenne. It thus also appears, from the wide separation of these several

localities, that the Anchylostomes, if duly sought for, will be found in many other countries."

These details given by Wucherer are so precise and instructive that I could not have further abridged them without injustice to his record. The bearing of the foregoing facts in relation to the question as to how we may hope to arrest the fatal action of many of these nematodes is sufficiently obvious. That strongyles and their allies prove highly destructive to man and beast is as well established as any other recognised conclusion in medical science; nevertheless, there are those who still doubt the power of these nematodes in relation to the production of fatal epidemics. I shall deal with the sanitary bearings of the subject hereafter. In conclusion, I may mention that Dr da Silva Lima has forwarded specimens of *Anchylostomum* to the Hunterian Museum, where they may be seen.

Bibliography (No. 29).—*Bilharz*, 'Zeitschr. f. wiss. Zool.,' Bd. iv, s. 55.—*Cobbold*, 'Entozoa,' p. 361.—*Idem* "Remarks on Recent Contributions to our Knowledge of the Parasitic Nematoids, especially in reference to the Wasting Diseases they produce in Man and Animals," the 'Veterinarian,' Jan, 1876, p. 1.—*Davaine*, l. c., pp. 118 and 931.—*Diesing* "Revis. der Nematoden," 'Sitzb. d. m.-naturw. cl. d. k. Akad.,' 1860, s. 716.—*Dubini*, 'Entozoografia,' &c., 1849.—*Griesinger* (quoted above), see also 'Arch. f. Phys. Heilk.,' 1854.—*Küchenmeister*, l. c., Eng. edit., p. 383.—*Leuckart*, l. c., ss. 410-455.—*Molin*, 'Il sottordine degli Acroffali,' p. 61 (quoted by Leuckart).—*Siebold*, 'Zeitsch. f. wiss. Zool.,' 1852, s. 55.—*Sonsino, P.*, *L'Anchilostoma duodenale* in relazione coll' Anemia progressiva perniciosa,' Egitto, 1877.—*Idem*, 'Sull.' *Anch. duod.*, 1878 (see also Bibliog. No. 27, both reprinted from 'Imparziale.')—*Weber, H.*, l. c., 1867.—*Wucherer* (quoted above), 1872.

Dracunculus medinensis, Cobbold.—This parasite is popularly known as the guinea-worm, or Medina-worm. Probably Lister was the first writer who distinctly spoke of it as the Dracunculus, 1690, the same title being applied to it by Kaempfer, 1694. Be that as it may, Gmelin, long afterwards, placed the parasite in the genus *Filaria*, at the same time adopting the specific title *medinensis*. This had been previously employed by Linneus, who, however, regarded the worm as belonging to the genus *Gordius*. It being clear from the distinctive characters of the entozoon that it was desirable to separate it from the Filariæ, and that no better generic name

could be devised than *Dracunculus*, I thought it right to combine Lister's and Gmelin's nomenclature as above, 1864. Leuckart pursued a similar course, crediting Linneus with the titles.

The guinea-worm having been known from the earliest times, it is not surprising that its true nature long remained a mystery. Any one who has read Küchenmeister's elaborate narrative of the historical significance of the Dracunculus will hardly have failed to arrive at the conclusion that Moses was probably the earliest writer on the endemic disorder which is occasioned by this parasite. There can be no doubt that the "fiery serpents" which afflicted the children of Israel during their stay in the neighbourhood of the Red Sea were neither more nor less than examples of our Dracunculus. It is further evident that Plutarch spoke of Dracunculi, when in the eighth book of his 'Symposiacon,' he quotes Agatharchidas as stating that the people taken ill on the Red Sea suffered from many strange and unheard-of attacks, amongst other worms, from "little snakes, which came out upon them, gnawed away their legs and arms, and when touched retracted, coiled themselves up in the muscles, and there gave rise to the most insupportable pains." In order to render the passage more readable, it will be seen that I have slightly altered the original version ('Parasiten,' s. 305).

The guinea-worm may be described as a nematode measuring from one to six feet in length, having a thickness of $\frac{1}{10}$th of an inch. The body is uniformly cylindrical, terminating below in a more or less curved and mucronately pointed tail. The head is flatly convex or truncate, having a central, simple mouth, which is surrounded by four equi-distantly and cruciately disposed papillæ. The mode of reproduction is viviparous, the body enclosing a prodigious number of hatched embryos, which, by distension of the uterine ducts, almost entirely obliterate the somatic cavity. Notwithstanding the statements of Owen to the contrary, the male Dracunculus is at present altogether unknown.

The guinea-worm possesses a comparatively limited geographical range, for not only is it proper to the tropical regions, but within intertropical limits it is almost exclusively confined to certain districts in Asia and Africa. Thus, according to Künsenmuller, as quoted by Busk, it occurs endemically in Arabia Petræa, on the borders of the Persian Gulf and Caspian Sea, on the

FIG. 42.—Outline of a female *Dracunculus medinensis*. Nat. size. Original.

banks of the Ganges, in Upper Egypt, Abyssinia, and the coast of Guinea. "In America the guinea-worm is unknown, except in persons who have had communication with Africa or other parts where it is indigenous. The island of Curaçoa is the only locality in the New World which offers an apparent exception to this fact, and it would be highly desirable to ascertain the real state of the case in this instance." The observations of Chisholm showed that the Dracunculus is really prevalent in several of the West Indian islands, especially in Grenada, and the still later investigations of Dr Da Silva Lima point to its former prevalence in Brazil. Now, the worm is rarely seen at Bahia. Mr Busk said:—"Though endemic only in the above-mentioned parts of the world, it would yet appear that all races of mankind are obnoxious to the attacks of the *Filaria* when exposed to what may be called the contagion; that is, when placed in circumstances under which it might be supposed a contagious *seminium* could be conveyed to them." Mr Busk also added:—"I have known many instances tending to prove that, in order that a European should become infected with the guinea-worm on the coast of Africa, it is not necessary that he should have been on shore at all. It has been quite sufficient for him to have exposed the bare surface of some parts of his person to the water in the native canoes alongside, or, it may be, to the discharge from the sores of those laboring under the disease. This mode of its introduction accounts for the frequency with which the legs and feet are attacked by the parasite, in preference to other parts of the body, as it will always, I believe, be found that the men who have become so affected have been in the habit of going about with bare feet, as is common among sailors in warm latitudes. That the contagious material is

conveyed in water is also further indicated by the well-known fact that in India, where it is the custom of the natives to carry water in skins on their backs, the worm makes its appearance on the back and shoulders and upper part of the body." These views were published by Busk in 1846, and I am free to confess that—confirmed as they appeared to be by subsequent and independent testimony—they completely dominated my conceptions as to the mode of ingress of the young parasites within the human bearer. Thus, those of our Indian troops which were most exposed during the rainy season, subsequently exhibited evidence of having been invaded by the Dracunculus. As, moreover, the period of incubation of the entozoon commonly extends from twelve to fifteen months, it necessarily happened that the disease often showed itself in localities far distant from the spot where the troops originally contracted the disorder. The statement that the period of incubation of the worm is not less than a year, is probably incorrect, since Carter mentions that in a school of fifty boys bathing in a certain pond at Bombay—the sediment of which swarmed with microscopic tank-worms (*Urobales palustris*, Carter)—twenty-one were attacked with Dracunculus during the year, whilst the boys of other schools, bathing elsewhere, remained, with few exceptions, uninfected. This is a remarkable occurrence, and it points to the possibility of the young Dracunculi being confined to particular pools. That they should, whether occupying the bodies of intermediary bearers or not, be more abundant in some waters than others, is just what might be expected, since such a distribution is in harmony with a recognised law affecting the abundance or limitation of species in particular localities. Much, indeed, has been written respecting the nature of the soil and geological formations occurring in the Indian worm-districts, but the speculative views enunciated on this point are little worthy of credit. Those who desire information on this head should at all events consult the valuable writings of Smyttan, Greenhow, Bird, Forbes, Chisholm, and Aitken, who, apart from the question at issue, supply abundance of practical information.

Into the anatomy of the adult Dracunculus I do not enter, but I may remark in passing, that the structure of the worm has been exhaustively treated of by Busk and Bastian. A *résumé* of their views is given in my introductory treatise. Carter and Leuckart have also added important details. As regards

the structure and development of the young worms, I have to observe that the discovery of the viviparous mode of reproduction in Dracunculus is due to Jacobson. Nearly a quarter of a century ago I recognised the fact that the uterine organs of the adult worm almost completely filled up the perivisceral cavity, and that they were crowded with microscopic worms. Referring

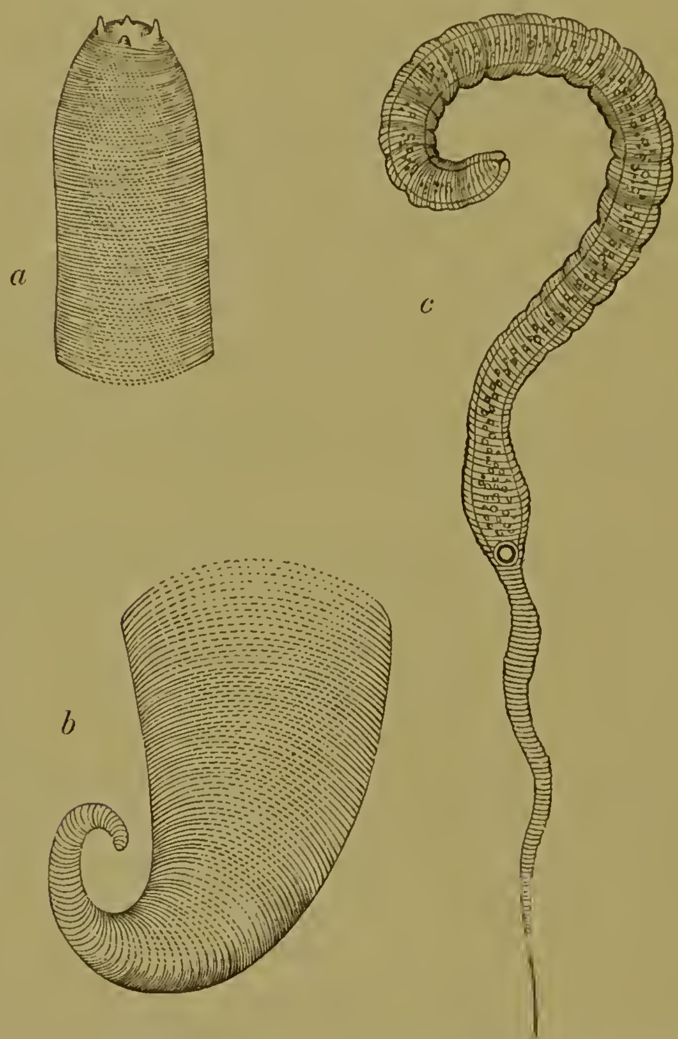

FIG. 43.—*a*, *b*, Head and tail of the adult guinea-worm (magnified 10 and 18 diameters respectively); *c*, embryo (magnified 500 diameters). Original.

to this "find," the late Sir George Ballingall, of Edinburgh, in his well-known work on 'Military Surgery,' recorded the circumstance in the following terms:—"The Assistant Conservator of the Anatomical Museum in our University has detected *in the oviduct* of an adult specimen from my collection myriads of minute and perfectly-developed (embryonic) Dracunculi. They can be very well seen with an half-inch object-glass, but their structure is best exhibited if the magnifying

power be increased to two hundred and fifty diameters linear." As already stated in my introductory treatise, these observations were made during the winter of 1853-54. In July, 1854, M. Robin made a similar statement after examining a fresh *Dracunculus* which had been extracted from the leg of a man by M. Malgaigne. Robin, not unsuitably, compared the worm to a double tube, one tubular sheath, as it were, enclosing the other. "The second tube," he distinctly affirms, "*is the oviduct, or, rather, that part which represents the uterus.* The young still remaining in the uterus were nearly all coiled, sometimes with the tail sallying outwards, at others rolled like the rest of the body." I have thought it only due to Robin and myself to show that from the first we were perfectly well acquainted with the fact of the "great development of the genital tube and of its close adherence to the parietes of the body." To be sure, many discrepancies occurred in our writings, and in those of Busk and Carter. It was Bastian's skill and good fortune to correct these errors. Thus, most of us agreed in recognising a slightly trilobed or tripapillated mouth; but Carter failed to demonstrate the existence of these tubercles, and spoke of the oral aperture as being simple and "punctiform." The body throughout its three upper fourths appeared to me to be cylindrical, but Robin found that it was flattened. It is finely striated transversely, except at the part where it contracts to form the slender, pointed tail. According to Carter, Robin, and Davaine, the young attain a length of about $\frac{1}{33}$ of an inch, but Bastian gives it as about $\frac{1}{42}''$. In thickness, Carter gives the approximative diameter as $\frac{1}{633}''$, Robin makes it $\frac{1}{990}''$ to $\frac{1}{1320}''$, whilst Bastian gives their breadth at $\frac{1}{1428}''$, and Davaine at $\frac{1}{2500}''$. I estimated their greatest length and breadth to be $\frac{1}{30}''$ by $\frac{1}{1000}''$. Robin and myself thought we recognised a distinct, rounded, anal orifice; and whilst Busk, on the one hand, saw nothing which in the slightest degree indicated the presence of an anal opening, Carter, on the other hand, described the structure which we called the anus as a gland, at the same time placing the alimentary outlet on one side and a little above it. According to Bastian, "the intestinal.tube is about $\frac{1}{87}''$ in length, and appears to consist of a simple canal of varying calibre, pursuing a nearly straight course, and terminating exactly at about the middle, in length, of the worm. Like Robin, Bastian recognised œsophageal and stomachal divisions, and in a few examples he observed the

cæcal or terminal portion of the intestine to be partially reflected upon itself. In regard to the circular opening which Robin and myself described as the anus, Bastian says there is a rounded body, "about $\frac{1}{2200}''$ in diameter, with a dark or light spot in the centre, according to the varying focal distance, and which seems to represent a central aperture. Sometimes, above this, traces of two or three large cells may be recognised, whilst behind nothing definite can be made out, save that the cavity of the body is visible for about $\frac{1}{400}''$. In other specimens of the young worm the central body and spot are wanting, but, in its stead, two lateral sacculi are met with, about $\frac{1}{3300}''$ in diameter, that communicate with the exterior by a minute channel through the integuments, which can sometimes be distinctly recognised. At other times the channel is obscured by protrusion, which appears to have taken place through it, of a minute bilobed papilla, projecting $\frac{1}{10,000}''$ from the side of the body. When the projections are seen, the sacculi are indistinct."

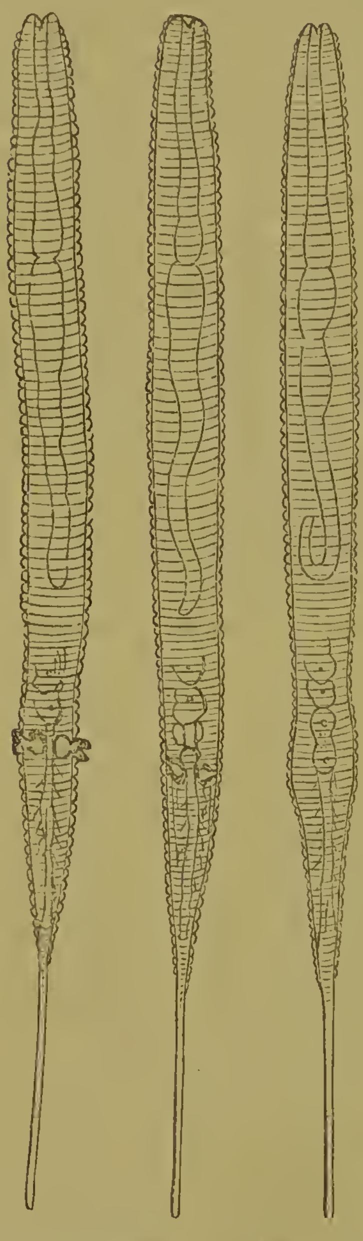

FIG. 44.—Embryos of *Dracunculus*. Magnified 500 diameters. After Bastian.

As Bastian found the young in all stages of development from the germ condition $\frac{1}{5000}''$ in diameter up to the perfect embryo, and as, moreover, he, like the rest of us, could detect no sexual orifice in the adult Dracunculus, he was led to express his belief that the young were produced agamo-genetically. He went so far as to call the germs *pseudova*. It was with great reluctance that I dissented from the views of so gifted an observer as Bastian; nevertheless, later researches have shown that I was justified in not hastily concurring in the theory of a non-sexual mode of reproduction for Dracunculus.

Among the many advances of modern helminthology, the discovery of the true source of the guinea-worm is not the least important. To the late M. Fedschenko (the lamented and

accomplished Russian traveller, who lost his life in a snow-storm on the Alps), science stands indebted for this memorable advance. Fedschenko showed that the embryos of Dracunculi, after quitting the human host, succeed in effecting an entry into the bodies of entomostracous crustaceans belonging to the genus Cyclops. Within these intermediary bearers, after twelve hours' sojourn, the embryos undergo a change of skin, attended with subsequent growth. Here they remain to complete their larval development, which takes place within a period of five weeks, or, as Fedschenko himself told me, one month and six days. At length, as perfected larvæ, they are, together with their crustacean hosts, transmitted to the stomach of the ultimate or human bearer. It is probable that sexual maturity is next acquired within the human stomach, copulation following. After this, the females migrate to the situations in which they are found beneath the skin of the human bearer, whilst the males perish and pass out with the fæces. Thus much I gathered from M. Fedschenko himself when he visited this country, and I possess a sketch of the larvæ made by him at the time (October 23rd, 1873). One of the figures represents a larva which has undergone ecdysis, the long and narrow embryonic tail being supplanted by one which is blunt and forked at the tip. The somatic contents of the embryo have at the same time differentiated into a complete intestinal tube, and a constriction marks the junction of the œsophagus with the stomach. There is also internally an oval-shaped mass of cells near the centre of the body. These represent the commencement of the reproductive organs.

What I had gathered from Fedschenko in conversation thus epitomises that which has since been much more fully stated by Leuckart; and it is only fair to add that the Russian traveller was led up to his discovery by the previous investigations of Leuckart respecting the young of Cucullanus. The Leipsic helminthologist had, indeed, specially instructed Fedschenko as to the probable source of Dracunculus.

It is often thus that science makes its clear advances, since a master-mind is needed to set others on the right track. The embryos of Cucullanus and Dracunculus bear a close resemblance to each other, and the similarity of the types is continued on, though not in the same degree, in the next stage of larval growth, after ecdysis. The higher larvæ of both have their tails trifurcate at the tip, the head of the Dracunculus-

larva being distinguished by the presence of a pair of papillæ. In the case of Cucullanus the embryos are, according to Leuckart, passively transferred to the stomach of Cyclops by the mouth; but in the case of Dracunculus, Fedschenko saw the embryo in the act of perforating the bodies of the little crustacea at the ventral surface, where the segments are bound together by a thin and easily penetrated connecting membrane. The larvæ then proceed to coil themselves within the limbs, as many as six or even a dozen of the parasites being occasionally found within the body of a single crustacean host. When they have reached full larval growth they measure about $\frac{1}{25}''$ in length. Of course, after attaining this stage, it is a matter of conjecture as to the precise way in which their final destiny is accomplished. Fedschenko fed dogs and cats with the infected crustacea, but failed to rear Dracunculi in these animals. Clearly, these carnivora were unsuitable hosts. Could Fedschenko have experimented on man the result would probably have been very different. Arguing from what happens in the case of Cucullanus amongst fishes, and Trichina in man, there can be little doubt that all the further and final changes undergone by the larvæ are accomplished within the human host. These changes are usually, if not invariably, consequent upon a direct transference of the infested entomostraca along with water used as drink. Thus, it must at once be evident that the simple sanitary precaution of filtering water before use is amply sufficient to ensure the prevention of attacks of dracontiasis or the guinea-worm disease. The theosophical remedy of Moses against this invasion by fiery serpents, as the worms were called in his time, and the modern prophylactic measures dictated alike by science and common sense, thus stand in striking contrast the one to the other. In the nature of things it must ever remain that unreason and reason will select diametrically opposite methods of action, equally, no doubt, with the good intention of bringing about beneficial results.

From what has now been advanced, it will be seen that as regards the mode of infection the views categorically expressed in my previous work ('Entozoa,' p. 387) cannot be maintained. What, however, is there stated in respect of *treatment* still holds good in the main, even as regards prophylaxis.

Bibliography (No. 30).—*Adam*, 'Trans. Med. and Surg. Soc.,' Calcutta, 1824.—*Aitken, W.*, 'The Science and Practice of Medicine,' 6th edit., vol. i, 1872.—(Anonymous), "Review of

the writings and opinions of Duncan, Johnson, Bird, Mylne, Kennedy, Chisholm, H. Scott, A. J. Robertson, Smyttan, Macgregor, Thomas, Mosely, Morehead, Twining, and others," on the Dracunculus or Guinea-worm," in 'Corbyn's India Journ. of Med. and Phys. Sci.,' vol. ii, p. 118, 1836.—(Anon.), "The Guinea-worm very Prevalent at Bokhara," 'Boston Med. and Surg. Journ.,' 1843, p. 387.—*Balfour, J.*, 'Ind. Ann. Med. Sci.,' 1859, p. 175.—*Ballingall, G.* (l. c., supra), 1854.—*Bastian, H. C.*, "On the Structure and Nature of the Dracunculus or Guinea-worm," 'Linn. Soc. Trans.,' vol. xxiv, p. 101, 1863.—*Berncastle, J.*, in the 'Lancet,' 1851.—*Bird, J.*, 'Calcutta Med. and Phys. Trans.,' 1825, p. 151.—*Bremser* (l. c., Bibl. No. 2), s. 194.—*Brett*, 'Surgical Diseases of India,' 1840; see also 'Med.-Chir. Rev.,' 1841.—*Bruce, N.*, 'Edin. Med. and Surg. Journ.,' 1806, vol. ii, p. 145.—*Busk, G.*, 'Micr. Soc. Trans.' (original series), 1846.—*Carter, H. J.*, "Note on Dracunculus in the Island of Bombay," 'Bombay Med. and Phys. Soc. Trans.' (new series), No. 2, p. 45, 1853-54; see also postscript, p. 252. —*Idem*, "Further Observ. on Dracunculus," 'Bomb. Med. and Phys. Soc. Trans.' (new series), No. 4, p. 215, 1857-58.—*Idem*, "On Dracunculus and Microscopic Filaridæ," 'Ann. of Nat. Hist.,' vol. iv (third series), 1859,—*Idem*, "Notes on Dracunculus," &c., 'Ann. of Nat. Hist.,' vol. ix (third series), 1862.—*Chapotin*, 'Bull. des Sci. Med.,' 1810.—*Charvet*, 'Ann. des Sci. Nat.,' 1834.—*Chiaje* (l. c., Bibl. No. 2), p. 99.—*Chisholm, C.*, "On the *Malis Dracunculus* or Guinea-worm (in Grenada)," 'Edin. Med. and Surg. Journ.,' vol. xi, 1815; see also the 'Veterinarian,' vol. ix, p. 508, 1836.—*Clark*, 'Med.-Chir. Rev.,' 1840.—*Clarkson, N. F.*, "Alleged Case in the Horse," the 'Veterinary Record,' 1845, p. 73.—*Clot-Bey*, 'Aperçu sur le ver dragonneau observé en Egypte,' 1830.—*Cobbold*, 'Entozoa,' p. 373.—*Cuvier*, 'Règne animal,' Orr's Eng. edit., 1849, p. 644. —*Davaine*, 'Traité,' l. c., edit. ii, p. 783 (full lit. refs.), 1878. —*Dickson*, 'Path. Soc. Trans.,' 1851.—*Drummond*, 'Med. Commentaries,' 1793, p. 294.—*Dubois*, 'Edin. Med. and Surg. Journ.,' vol. ii, 1806.—*Duncan*, 'Calcutta Med. and Phys. Soc. Trans.,' 1835.—*Ewart, J.*, "Questions relating to Dracunculus," in a review of his memoir on the "Vital Statistics of the Meywar Bheel Corps," in the 'Madras Quart. Journ. of Med. Sci.,' vol. i, 1860, p. 462.—*Fedschenko*, 'Protocol of the Promoters (Freunde) of the Natural and Physical Sciences at Moscow' (in the Russian language), 1869 and 1874 (quoted by Leuckart).—

Forbes, D., " Observ. on Dracunculus" (extr. from the 'Half-yearly Reports of the diseases prevailing at Dharwar in the 1st Grenadier Regiment, in the year 1836'), 'Bombay Med. and Phys. Soc. Trans.,' vol. i, 1838, p. 215.—*Gibson, A.*, " Note on the Prevalence of Dracunculus," in his remarks on the " Diseases of the Deckan," in 'Bomb. Med. and Phys. Soc. Trans.,' vol. ii, 1839, p. 209.—*Gramberg*, 'Geneeskundige tijdschrift voor nederl. Indie,' 1861, p. 632 (quoted by Leuckart).—*Greenhow, H. M.*, 'Indian Ann. of Med. Sci.,' vol. vii, 1861, p. 31.—*Grierson, D.*, " Observ. on the Dracunculus, as it prevailed in the 22nd Regiment, N.I., from April till September, 1841," 'Bomb. Med. and Phys. Soc. Trans.,' No. 4, 1841, p. 90.—*Grundler*, in 'Commerc. Litt. Nov.,' 1740, p. 239.—*Henderson, J.*, " Note respecting Four Cases of Dracunculus in the 48th Regiment," 'Madras Quart. Journ.,' vol. iii, 1841, p. 353.—*Horton, J. A. B.*, 'Army Med. Reports,' 1868, p. 335.—*Kennedy, R. H.*, 'Calcutta Med. and Phys. Soc. Trans.,' 1825, p. 165.—*Küchenmeister* (l. c., Eng. edit.), p. 389.—*Leuckart* (l. c., Bibl. No. 1), s. 644-725. *Lewis, T. R.*, in 'On a Hæmatozoon,' &c. (l. c., Bibl. No. 23), p. 30 *et seq.*—*Lima, Da S.*, "Remarks on the *Filaria medinensis*, or Guinea-Worm; on the occurrence of this Parasite endemically in the Province of Bahia; on its entrance into the human body by drinking water," in the 'Veterinarian,' Feb., March, *et seq.*, 1879.—*Lister*, 'Phil. Trans.,' 1690, p. 417.—*M'Clelland, J.*, 'Calcutta Journ. of Nat. Hist.,' vol. i, 1841, p. 366.—*M'Grigor, J.*, " On the Guinea-worm " (in his " Account of the Diseases of the 88th Regiment in Bombay "), 'Edin. Med. and Surg. Journ.,' vol. i, 1805, p. 284.—*Morehead, C.*, 'Calcutta Med. and Phys. Soc. Trans.,' vol. vi, 1833, p. 418; also noticed in 'Edin. Med. and Surg. Journ.,' vol. xliv, 1835.—*Idem*, part ii, 'Calcutta Med. and Phys. Soc. Trans.,' vol. viii, 1836-42.—*Murray, J.*, " Guinea-worm a very Common Disease at Sattara " (in his Official Report on the Hospital, &c.), 'Bombay Med. and Phys. Soc. Trans.,' No. 9, art. vi, p. 198, 1847.—*Oke, W. S.*, " Case of Guinea-worm," 'Prov. Med. and Surg. Journ.,' vol. vi, 1843.—*Oldfield*, " Case of Dracunculus " (from Laird and Oldfield's " Narrative of an Expedition into the Interior of Africa "), 'Dublin Journ.,' vol. xii, 1838.—*Paton*, " Cases of Guinea-worm," 'Edin. Med. and Surg. Journ.,' vol. ii, 1806.—*Raddock*, " A Case of Guinea-worm," 'Indian Med. Gaz.,' Oct., 1877, p. 265.—*Scott, W.*, " Remarks on the Dracunculus," in a letter to the Medical Board, Madras, 'Edin.

Med. and Surg. Journ.,' vol. xvii, 1821.—*Leverance, C. E.*, "History of a Case of Guinea-worm," from 'Amer. Med. Times,' in the 'Glasgow Med. Journ.,' vol. ix, 1861-62, p. 377.—*Smyttan, G.*, "On Dracunculus," 'Calcutta Med. and Phys. Soc. Trans.,' vol. i, 1825, p. 179.—*Stewart, L. W.*, 'Indian Ann. of Med. Sci.,' vol. vi, 1858, p. 88.—*Twining, W.*, "Cases of Dracunculus," 'Calcutta Med. and Phys. Soc. Trans.,' vol. vii, 1835.

Oxyuris vermicularis, Bremser.—Of all the parasites infesting the human body this is the one concerning which the medical practitioner is most frequently consulted, partly on account of its remarkable frequency in children, and more particularly on account of the difficulty often experienced in getting permanently rid of it. The *Oxyuris vermicularis* is by no means confined to young persons, seeing that adults are infested even to old age. It is familiarly known as the threadworm or seat-worm. The male measures about $\frac{1}{6}''$, and the female from $\frac{1}{3}''$ to $\frac{1}{2}''$ in length. The female possesses a long capillary tail, which terminates in a three-pointed end. The extremity is said to act as a kind of holdfast. The tail of the male is obtusely pointed. In both sexes the body presents a more or less fusiform shape, the anterior end being narrowed to form a somewhat abruptly-truncated head, which is often rendered very conspicuous by a bulging of the transparent integument surrounding the mouth. This presents in profile the aspect of winged appendages (fig. 45). The oral opening is tripapillated,

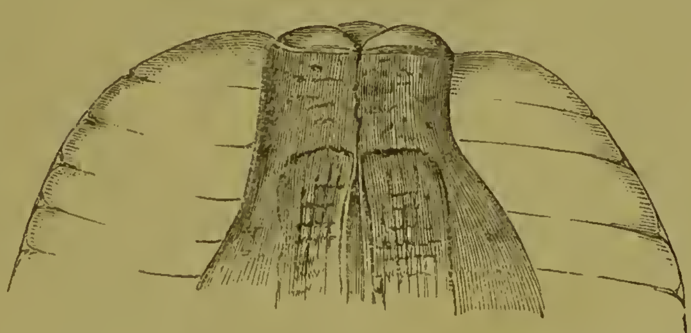

FIG. 45.—Head of *Oxyuris vermicularis*. Highly magnified. After Busk.

leading into a triangular œsophagus. The integument is transversely striated, and of a silvery-white appearance. The spicule is simple, single, and very minute. The eggs are oblong and unsymmetrical. They measure about $\frac{1}{500}''$ from pole to pole, and $\frac{1}{1100}''$ transversely.

Many years back (1863) I pointed out that the most advanced

eggs whilst still within the body of the pregnant female contained tadpole-shaped embryos, and about the same time the fact was noticed by Claparède. In his beautiful and scholarly memoir, 'De la formation et de la fécondation des œufs chez les vers Nématodes,' he wrote concerning the ova as

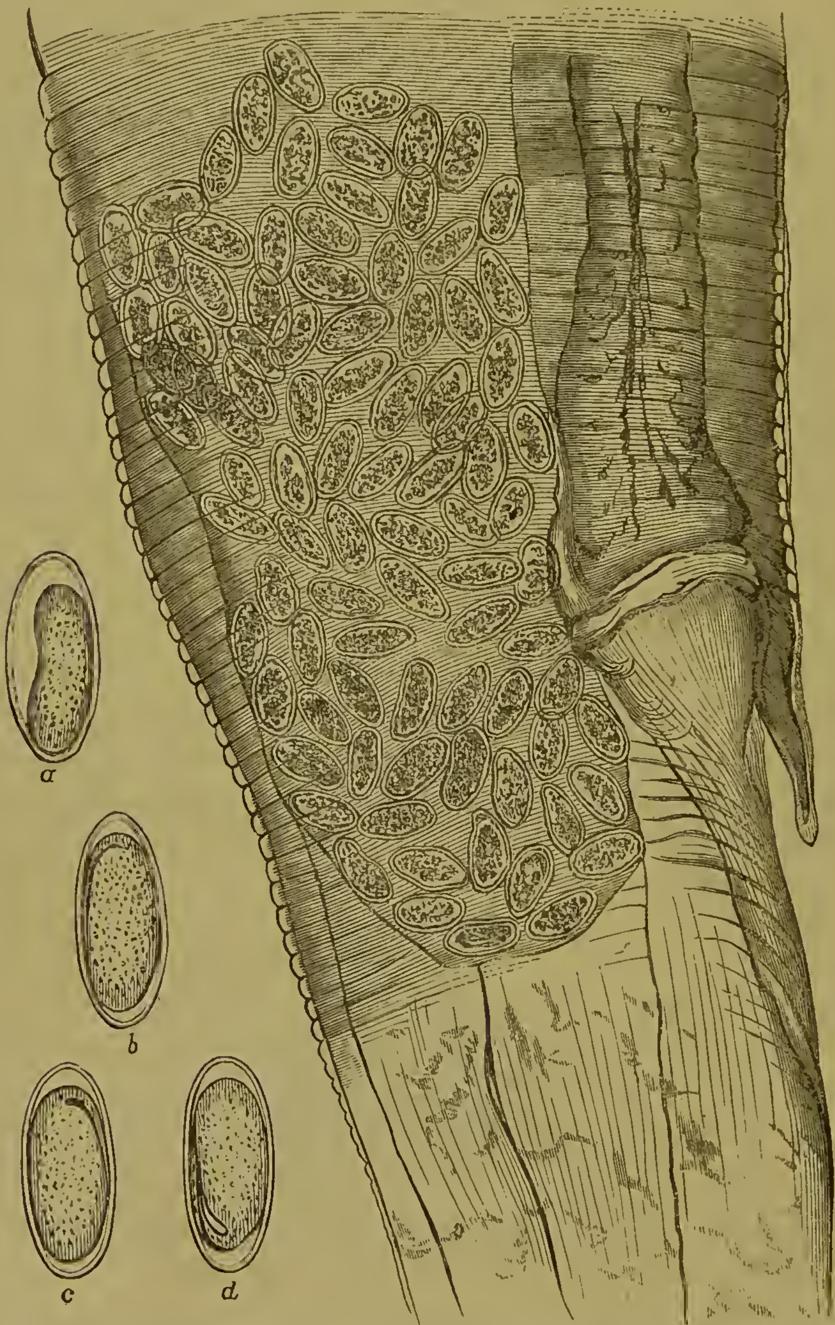

FIG 46.—Section of a female *Oxyuris vermicularis*, magnified 220 diameters (after Busk); and also several free eggs (original). *a*, With an imperfectly formed embryo; *b*, *c*, *d*, with three tadpole-shaped embryos, magnified 450 diameters.

follows:—"The egg, which exhibits the form of a very narrow disk in the ovary, acquires the shape of an elongated ellipsoid in the oviduct, and at the surface differentiates itself into a very

thick vitelline membrane. Then it forms a strong and resisting chorion, which imparts to the egg an outline similar to that of a bridge's span. It has an oval figure flattened at one of its sides. This chorion is very fragile; it frequently gives way under slight pressure from the thin plate of glass which covers the object. It extends itself considerably under the action of acetic acid, acquiring a size three or four times greater than that of the egg. The constitution of this chorion is perfectly identical in the eggs both before and after impregnation. It is, nevertheless, easy at first sight to know whether or not we have to deal with a fecundated egg. In the impregnated females the uteri are filled with thousands of ova, each one of which encloses an embryo already well formed. The ventral surface of the embryo and the tail are, without exception, applied to the flattened side of the egg. The embryo is very broad in the body, and occupies all the interior space. An embryo such as Küchenmeister has represented under the form of a small filiform worm folded on itself, and only occupying a very small part of the cavity of the egg, is never to be seen. In the non-fecundated females, on the other hand, the uteri are filled with eggs, which, instead of the embryo, enclose a non-segmented yolk furnished with a large germinal vesicle. This vesicle is not visible so long as the eggs have the form of thin disks; it only shows itself when the eggs begin to acquire an elliptical form in the oviduct. It is, however, probable that this vesicle is the same which was originally visible in the ovary." The chorion itself is homogeneous, but in an allied species (*Oxyuris spirotheca*) Gyoery and Claparède found that this egg-covering consists of spirally-coiled bands resembling the tracheal spiral fibre of an insect. Under suitable conditions the tadpole-shaped embryos rapidly assume a vermiform character. The investigations of Leuckart have shown that "one only needs to expose the eggs to the action of the sun's rays in a moistened paper envelope when, at the expiration of five or six hours, the tadpole-shaped embryos will have already become slender elongated worms." According to Heller, the simplest way to rear the vermiform stage of Oxyuris is to put a number of the eggs in a glass tube filled up with saliva. The tube should then be placed in the arm-pit, in which situation it can be carried about with little inconvenience. In a few hours the transformations will commence and go on continuously until the vermiform condition is attained. If, as remarked in my

'Lectures,' it be asked whether the embryos which have escaped into the bowel are capable of arriving at the vermiform stage, the answer is in the affirmative; for, as Leuckart says, "the elongated embryos are to be found not only in the fæces but also in the mucus of the rectum above and around the anus." Vix has also asserted that free vermiform embryos are occasionally to be detected in the intestine of the human bearer along with the eggs; this hatching within the lower bowel, however, must, in my opinion, be regarded as exceptional. Heller is of the same opinion. According to Leuckart, the escape of the embryos from the eggs "ordinarily takes place under the action of the gastric juice, also primarily in that condition when they have by some means or other gained access to a new bearer." Prof. Leuckart and three of his pupils courageously infected themselves by swallowing the eggs, and had the satisfaction of observing young Oxyurides in their stools fifteen days afterwards.

From the united labors of Professors Zenker and Heller it is now rendered certain that all the further changes necessary to bring the larvæ to sexual maturity are accomplished within the small intestines of the human bearer; and it is not necessary that a change of hosts should occur at any time during the life of the parasite. Infection ordinarily takes place by the accidental and direct conveyance of the eggs that are lodged in the neighbourhood of the victim's anus to the mouth. Since the victim may accomplish this during sleep, it is not in all cases fair to charge infected persons with uncleanliness. On the other hand, it too often happens that due care in this respect has not been exercised, and from such persons you may remove the eggs of Oxyurides from the margins of the finger nails. One aristocratic person, who was infested by myriads of these entozoa, confessed to me that in his extreme distress, and consequent rage, he had freely bitten the live worms in halves between his teeth. He had thus exposed himself to a terrible revenge, since multitudes of the ova entering his mouth subsequently found their way into the stomach and intestines. By whatever mode the eggs are conveyed to the mouth their subsequent passage to the stomach ensures their being hatched. In the duodenum and other divisions of the small intestines, as Zenker and Heller have shown, the embryos undergo transformation, casting their skins, and growing with great rapidity. Probably not more than three weeks or a month is necessary to complete

their growth. Heller obtained mature worms from an infant only five weeks old. Finally the worms are transferred to the cæcum, which constitutes, so to speak, their headquarters. It is an error to suppose that the lower bowel or rectum forms their especial habitat, nevertheless the most approved manuals, vade mecums, and general treatises have for a long time supported this erroneous view. The error had been pointed out by Stricker in 1861.

The symptoms produced by Oxyurides are occasionally very serious. In the mildest cases they have a tendency to undermine the health. As remarked in my 'Entozoa,' the unpleasant sensations chiefly develop themselves in the evening and at night, consisting for the most part of feelings of heat and irritation within and around the margin of the anus. The symptoms may become extremely distressing and almost intolerable, especially when the itching extends to the genito-urinary passages, in consequence of the escape and migration of the parasites about these parts. By-and-by various sympathetic phenomena, such as restlessness, general nervousness, itchings at the nose, involuntary twitchings, grinding of the teeth during sleep, chorea, convulsions, and even epileptiform seizures, may supervene. At the age of puberty special local disorders arise, the nature of which will be readily understood when merely spoken of as the morbid phenomena of sexual irritation. In the female the occurrence of pruritus and leucorrhœa is not uncommon, accompanied or not, as the case may be, with hysteria in various forms. There is usually general asthenia, with more or less emaciation. The anæmia is sometimes remarkable, but in place of anorexia, which is, however, an occasional symptom, one frequently finds a most voracious appetite, especially in young people. Some-

FIG. 47.—Adult male *Oxyuris vermicularis*. Magnified. After Küchenmeister.

times there are obscure symptoms simulating those of local organic disease.

About the treatment of the disorder I have nothing to say here, further than to urge the benefits of the preventive measure of cleanliness. Like Zenker and Heller, I have obtained the eggs of oxyurides from beneath the finger-nails of young people. In one lad all the nails had been carefully bitten down to their roots, but from beneath a minute projecting portion that was left on the right fourth-finger I procured two eggs. Their demonstration under the microscope convinced both parent and child of the necessity of frequently employing local and general ablutions. Personal cleanliness is essential. In this connection an able biologist has ventured to hazard a statement to the effect that "probably any infected person who adopted the requisite precautions against reinfection from himself or others would get well in a few weeks without treatment by drugs." Dr Ransom bases his belief on the known facts of the life-history of this entozoon, as recorded more especially by Leuckart. I regret that I cannot fully share Dr. Ransom's views, and still less should I think it right by my silence to seem to endorse his statement to the effect "that every person who is shown to be infested with those very common entozoa, *Oxyuris vermicularis* and *Trichocephalus dispar*, is thereby demonstrated to have swallowed minute portions of his own or another person's fæces." This is putting the case too strongly. No doubt the eggs of oxyurides swallowed by ourselves must have previously passed through some person's rectum; as such, either separately or mayhap collectively, in the body of the maternal parasite. That does not, however, justify the statement, that we "have swallowed" part of our own or of some other person's excrement. The eggs ought not to be regarded as constituent portions of the fæcal matter. Perhaps Dr Ransom will say that the surfaces of these eggs, being in contact with fæcal matter, must carry infinitesimal particles on their surfaces, and it is to such that he refers. As, however, a large proportion of the ova escape with their parents, whilst they are still lodged within the maternal worm, it cannot be held that these intra-uterine ova carry fæcal matter on their shells. Commonly the eggs are swallowed in the separate, free, and dry state. In water they perish quickly. The act of eating with unwashed hands is a fertile source of infection, more especially if the meal be taken either in bed or in the bedroom.

Bibliography (No. 31).—*Alexander, J.*, "On Vermination," 'Lancet,' 1833.—*Anderson, W.*, "On Santonine, with especial reference to its use in Roundworm and Threadworm," 'Brit. Med. Journ.,' April, 1864, p. 443; also in Braithwaite's 'Retrospect of Medicine,' vol. xlix (synopsis, p. 20), 1864.—*Barry, J. M.*, "On the Origin of Intestinal Worms, particularly the *Ascaris vermicularis*," 'Trans. Assoc. of Fell. and Licent. of King's and Queen's Coll. of Phys. in Ireland,' vol. ii, 1878, p. 383.—*Bremser*, l. c., s. 79.—*Buckingham*, "Ascarides causing Erotomania," from 'Bost. Journ., U.S.,' in 'Med. Gaz.,' 1857.—*Claparède, E.*, "On the Formation of the Egg and Fertilisation in the Nematoidea," from the 'Zeitsch. f. w. Zool.,' translated by Dallas in 'Ann. Nat. Hist.,' vol. i (third series), 1858.—*Idem* (memoir quoted in the text above), Genève, 1859.—*Cobbold, T. S.*, 'Worms,' Lect. xii-xv, 1872.—*Idem*, 'Entozoa,' p. 362.—*Idem*, 'Brit. Med. Journ.,' Aug., 1873.—*Idem*, 'Tapeworms and Threadworms,' 2nd edit., 1872.—*Idem*, 'Lancet,' 1866.—*Idem*, "On the Development and Migrations of the Entozoa," 'Brit. Assoc. Rep.,' 1864, p. 116.—*Date, W.*, 'Lancet' for Feb., 1872, p. 185.—*Davaine*, 'Traite,' l. c., 2nd edit., p. 211, and 'Synops.,' p. 95.—*Dickinson*, "Case of Epilepsy in Children relieved by the expulsion of Worms," 'Med. Times and Gaz.,' Jan., 1863.—*Dickson, R.*, art. "Anthelmintics," rep. from the 'Penny Cyclopædia,' in Knight's 'Eng. Cyclop. Arts and Sci. Div.,' vol. i (column 365), London, 1859.—*Dreyfus*, "Irritation of the Bladder from Ascarides," from 'Journ. de Med.,' in 'Lond. Med. Gaz.,' 1847.—*Elliotson, J.*, "A Lecture on Worms," 'Lond. Med. Gaz.,' 1833.—*Idem*, "On Worms in the Intestinal Canal," 'Lancet,' 1831.—*Idem*, "On a Case of Threadworms," 'Lancet,' 1831.—*Idem*, "On Intestinal Worms," 'Lancet,' 1830.—*Heller, A.*, "Darmschmarotzer," in von Ziemssen's 'Handbuch,' Bd. vii, s. 632 (see also Anglo-American edit.), 1876—*Küchenmeister*, l. c., Eng. edit., p. 356.—*Ransom*, in 'Reynolds' 'Dictionary of Medicine.'—*Smith, A.* (and others), 'Lancet,' April 29th, 1865, p. 468.—*Stricker, W.*, in 'Virchow's Archiv,' xxi, 1861, s. 360.—*Tatham*, 'Lancet,' April, 1867, p. 457; see also p. 519.—*Vix, E.*, 'Ueber Entozoen,' &c., Berlin, 1860; see also "On the occurrence of Entozoa in the Insane, particularly with respect to the *Oxyuris vermicularis*;" brief notice ('Allg. Zeitsch. f. Psychiatrie') in Winslow's 'Journ. of Psycholog. Med.,' vol. i, 2nd series, 1861, p. 158.—*Zenker*, 'Verhandl. d. phys. med. Soc.,' H. ii,

Erlangen, 1870, s. 20; and in 'Tageblatt der deutschen Naturforscherversammlung zu Dresden,' 1868, s. 140 (also quoted freely by Leuckart, Davaine, and Heller).

Leptodera (*Anguillula*) *stercoralis*, Bavay.—In the summer of 1876 Dr Normand, of the French Marine, discovered this little entozoon in the fæcal discharges of soldiers who had been sent home invalided from Cochin-China. The patients in question were the victims of the so-called Cochin-China diarrhœa or dysentery. This disorder is endemic in character, and it had hitherto been regarded as consequent upon a variety of causes other than parasitic. Dr Normand's discovery, as such, therefore takes equal rank with the analogous revelations made by Bilharz, Harley, Leuckart, Zenker, Weber, Lewis, and Bancroft, in respect of the particular helminthiases in man with which their names are severally associated (Bilharzia disease, Endemic hæmaturia, Cestode tuberculosis, Olulaniasis, Inter-tropical anæmia, Trichinosis, Lymphoid affections, Helminthoma, and so forth), and also, if I may be permitted to say so, with my own determinations in respect of a variety of endemics affecting animals (cestode and nematode epizöoty in the horse, the so-called grouse-disease, the pigeon-endemic due to lumbricoids, &c.).

The *Leptodera stercoralis* is a minute, smooth-bodied, simple, rhabditiform nematode, measuring when full grown $\frac{1}{25}''$ in length, with an average breadth of $\frac{1}{625}$ of an inch. The embryos at the time of their extrusion measure only $\frac{1}{250}''$ in length, but by the time at which a rudimentary vesicle representing the uterus begins to form, the females have already attained a length of about $\frac{1}{83}''$. The males and females are of nearly equal size. The transition from the embryonal state to the higher larval conditions is accompanied by a change of skin, after which the digestive and reproductive organs are gradually but rapidly formed and completed. These changes have been minutely traced and recorded by Professor Bavay, who also compares the entozoon with the genera Rhabditis and Leptodera, in either of which genera the worm might be placed. I have accordingly adopted the nomenclature suggested by Bavay.

As happens in all the kindred helminthiases that are known to be dependent upon the presence of small worms, large numbers of Anguillules are necessary to produce injurious effects upon the bearer. Thus, the evacuations of the Cochin-

China patients were found to contain such multitudes of the worms that their numbers could only be adequately estimated at so many hundreds of thousands passed in twenty-four hours. Of course they varied in quantity, not only in different patients,

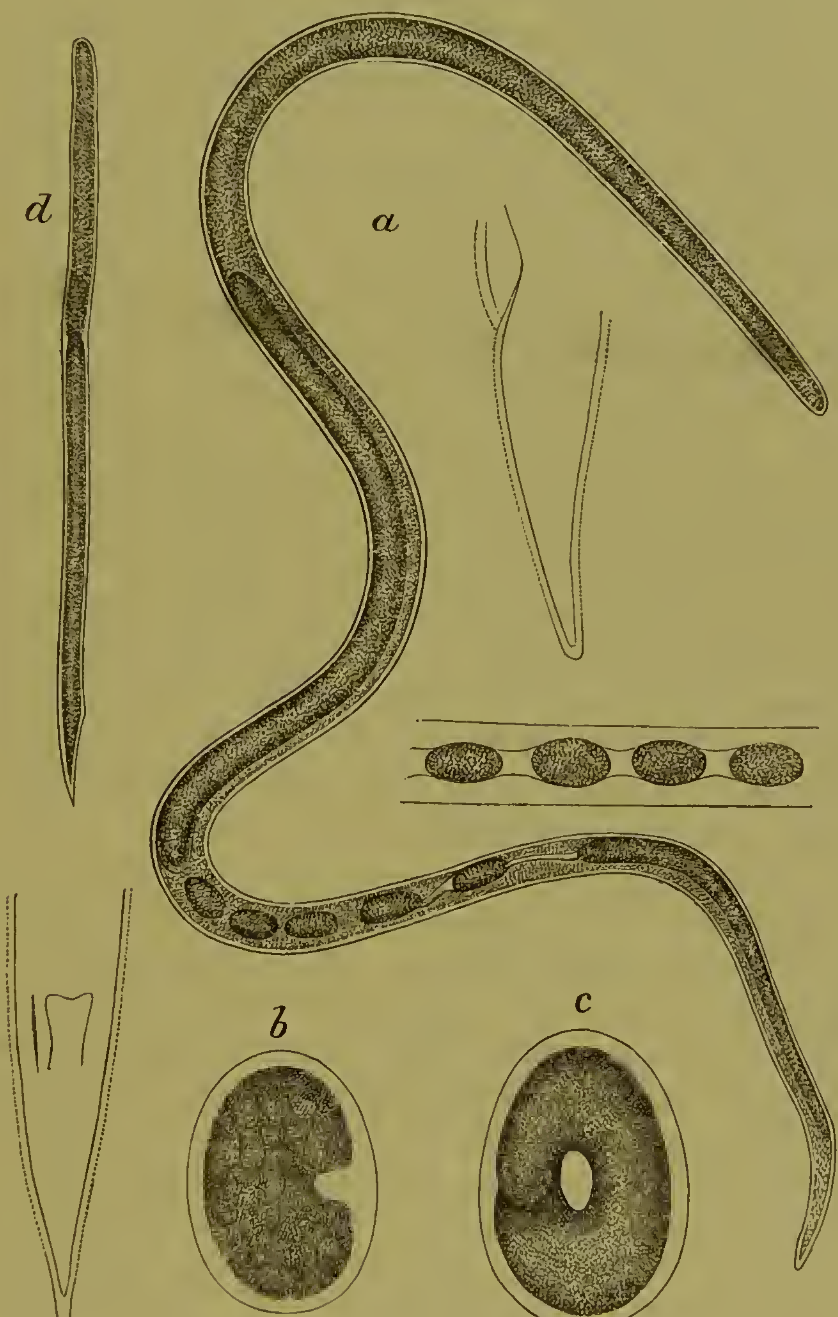

Fig. 48.—*Leptodera intestinalis.* *a*, Adult female, and separate figure showing a portion of the body with the ova *in situ*. The two outlined figures represent profile and front views of the tail, respectively. *b*, *c*, Eggs with imperfectly formed embryos. *d*, Larva. Highly magnified. After Bavay.

but in the same bearer, from day to day. They are to be found in every stage of growth and development, from that of the intra-ovular embryo and free embryonic state up to sexual maturity. They occupy all parts of the intestinal canal, from

the stomach downwards, being also found in the pancreatic and biliary ducts, and likewise within the gall-bladder. According to Bavay, five days suffice under favorable circumstances for the complete maturation of the worm. This readily accounts for their occasional extreme abundance.

I am indebted to the courtesy of Dr le Roy de Méricourt for the original memoirs from which these brief abstracts are taken.

Leptodera intestinalis, Bavay.—This is a larger species, now and then found associated with the above, and, according to Bavay, "in infinitely less abundance." This species was also discovered by Dr Normand, and has been carefully described by Bavay. Possibly the worm may afford us another curious instance of dimorphism. Be that as it may, it must be provisionally regarded as a distinct form. As its occurrence is by no means invariable, its rôle in relation to the Cochin-China diarrhœa must, as Davaine has likewise remarked, be regarded as of secondary importance. It is readily distinguished from *A. stercoralis* both in the adult and larval conditions. The full grown worm, although comparatively narrow, is more than twice as long as its congener; moreover, the larvæ, in place of possessing finely-pointed tails, have blunt or truncated caudal extremities. Converting M. Bavay's millimetric measurements into fractions of the English inch, the average length of the mature worms will be about $\frac{1}{11}''$, whilst their breadth does not exceed $\frac{1}{757}''$ in diameter.

Bibliography (No. 32).—*Bavay*, "Sur *l'Anguillule stercorale*," 'Comptes Rendus,' Oct., 1876, p. 694, also in 'Ann. Nat. Hist.,' vol. xviii, 4th series, p. 507, 1876, also noticed in the 'Veterinarian,' Jan., 1877, p. 19.—*Idem*, "Note sur *l'Anguille intestinale*," 'Archiv. de Méd. Nav.,' July, 1877, p. 64, and in 'Ann. Nat. Hist.,' 1877, vol. xix, 4th series, p. 350. —*Cobbold, T. S.*, "Parasites of Man," in the 'Midland Naturalist' for January 1st, 1879.—*Davaine*, 'Traité,' l. c., 2nd edit., Supp., pp. 966-976, 1877.—*Laveran*, in 'Gaz. Hebd. de Med.,' Jan., 1877, p. 42.—*Layet* and *Le Roy de Méricourt*, in 'Dict. Encycl. des Sci. Med.,' 1875.—*Libermann*, in 'Gaz. des Hôp.,' March, 1877, p. 237, and in 'La France Méd.,' 1877, p. 165 (quoted by Davaine).—*Méricourt* (see Layet).—*Normand, A.*, in 'Comptes Rendus' for July, 1876, p. 316, and Aug., 1876, p. 386.—*Idem*, in 'Arch. de Méd. Navale,' 1877, p. 35, and separately as 'Mémoire sur la diarrhée dite de Cochinchine,' Paris, 1877.—*Idem*, "Du rôle étiologique de l'Anguil-

lule dans la diarrhée de Cochinchine," in 'Archives de Médecine Navale' for September, 1878, pp. 214-224.

Ascaris mystax, Rudolphi.—This well-known helminth possesses aliform appendages, one on either side of the head. It is of a medium size, the male measuring $2\frac{1}{2}''$ and the female usually $3\frac{1}{2}''$ to $4''$ in length. Both as regards the size of the alæ and the length of the body it varies in different hosts. Thus the variety infesting the dog has long been regarded as a distinct species (*A. marginata*), partly from the circumstance that the alæ are less conspicuous, and partly because the individuals are often longer and thicker. I possess one specimen from the dog measuring more than six inches in length. From like causes the *Ascaris leptoptera* and other varieties infesting the carnivora have been regarded as distinct species, but the worm also varies in one and the same host.

As remarked in my elementary treatise, the late Dr Bellingham, of St Vincent's Hospital, Dublin, published in the 13th vol. of the 'Annals of Natural History,' an extended catalogue of Irish entozoa, and in this list he recorded the existence of a new round worm in man. He says of it:—"From the distinctness of the lateral membranes of the head I have given it the name of *Ascaris alata*." The catalogue was constantly referred to by Dujardin, Diesing, and other systematists; but some of the continental helminthologists do not appear to have had access to Dr Bellingham's more extended account of this parasite as given in the first volume of the 'Dublin Medical Press,' No. 7, Feb. 20th, 1839. I am led to this inference from the doubt which some have cast upon the very existence of the worm, although others, with more candour, supposed that Bellingham had only mistaken the species. Thus, Küchenmeister ('Parasiten,' s. 464, and in Lancaster's edit., vol. ii, p. 100) says:—"The *Ascaris alata*, found in the small intestines of a man, is probably only a young individual of one of the long-known nematoda, *if, indeed, it be a worm at all!*" (The italics are mine.) This statement was reproduced by Hulme in his English edition of Moquin-Tandon's 'Elements of Medical Zoology,' p. 341; and the French author himself evidently shared the doubt expressed by other people. Dujardin ('Helminthes,' p. 156) admitted the species, as also did Diesing ('Systema Helminthum,' p. 175), but the latter unluckily added the following very significant suggestion:—"An *Ascaris lumbricoides* capitis epidermide emphysematice inflata?"

Dr Leidy, of Philadelphia, admitted *A. alata* among his *Entozoa hominis* without comment ('Smithsonian Contrib.' for April, 1853), but Weinland, of Frankfort, in his list, prefixed a note of interrogation, observing also that it had been "once" found in Ireland ('Essay on Tapeworms,' p. 88). It is quite clear, therefore, that these authors did not believe that the *Ascaris mystax* was a human parasite. Those who doubtfully accepted Bellingham's *A. alata* did so under the impression that whatever it was, it could not be regarded as the common Ascaris of the cat. In the new edition of Davaine's 'Traité,' *A. alata* is, to my surprise, still retained as a separate species, and there is no mention of the occurrence of *A. mystax* in man. From what has recently been written by several continental helminthologists (Leuckart, Heller, and others), I rejoice to think that it is not necessary for me again to advance the really superabounding proofs that Bellingham's *A. alata* was nothing more than *A. mystax*. It has at length been admitted by almost all who are competent to form an opinion, that the memoir originally communicated to the 'Lancet,' in 1863, and subsequently introduced into the text of my introductory work, finally settled the question of identity. It was through the donation of Dr Edwin Lankester and Mr Scattergood that I was enabled at the time to announce the *third instance* of the occurrence of this parasite in man, and since that date several other instances have been brought under public notice. Not less than seven cases have now been noticed in which this little lumbricoid of the cat and dog has been found in man. For one good human specimen I am indebted to Dr Morton. In the above list I include Heller's specimen, and the one from Greenland sent by Steenstrup to Leuckart. According to Hering's observations this worm grows with remarkable rapidity. Worms obtained from a puppy only six days old measured from $\frac{1}{12}''$ to $\frac{1}{6}''$ in length. In a twelve-day-old puppy they reached nearly an inch in length, and in a month the growth was up to four inches. Females only $1\frac{1}{2}''$ in length already contained eggs, and males only $\frac{3}{4}''$ long had acquired their spicules. Three weeks therefore, would be amply sufficient for the completion of sexual maturity within the feline or canine host. We do not know, however, whether or not a temporary host is necessary for the larvæ prior to their introduction into the cat or dog. Hering thinks that a direct infection by the ova is sufficient; but he gives no proof of the truth of this hypothesis. "Leuckart (as quoted by Heller,

l. c., s. 615) found numerous embryonal round worms in the stomach of a cat, $\frac{1}{62}''$ in length, and in addition all the intermediate stages of growth up to the larger examples found in the small intestine. They remain in the stomach until they have attained a length of from $\frac{1}{18}''$ to $\frac{1}{12}''$ and then pass into the small intestine. When they have attained a length of nearly $\frac{1}{3}''$ they cast their skins and change the tooth-like boring apparatus for the three characteristic semicircular lips. These observations on *Ascaris mystax* (adds Heller) render it probable that *A. lumbricoides* is also introduced into the human alimentary canal while still in the embryonal state or somewhat further advanced (und wohl auch grösse)." The subject will be found more fully discussed in my account of the large species further on. The cat's worm possesses an historical interest, not only in connection with Bellingham's original discovery, but also in respect of Nelson's subsequent determinations as to the precise mode of impregnation in nematodes. The subject is too extended and too special to be dealt with here at any great length.

For several years after Nelson left the shores of England to spend a too short life in New Zealand, the points discussed in his 'Edinburgh Thesis' (and subsequently published in the 'Philosophical Transactions') formed the subject-matter of numerous memoirs contributed to the leading German scientific journals. Stated with brevity, it may be said that, according to Nelson, the essential act of impregnation occurs when the thimble-shaped spermatozoa of the male penetrate the unimpregnated or ovarian ovum. This, he maintained, could and did take place at any part of the surface of the unfertilised ovum, since the granular mass of which it was composed, though well defined, did not, at this period, possess a limiting—or true yolk—membrane. Professor Allen Thomson, in a series of papers (some contributed in the German language), supported Nelson's views generally.

Amongst Nelson's chief opponents was Meissner, who demonstrated that the unimpregnated ova really possessed a delicate limiting membrane, and that consequently the action of the spermatozoa was restricted to that portion of the ovarian ovum which became exposed by rupture or separation from the rachis. This opening he termed the micropyle. The union of the sexual elements is quickly followed by a condensation of the yolk-granules, and by the disappearance of the hitherto centrally placed germinal vesicle. The ovum next assumes a dis-

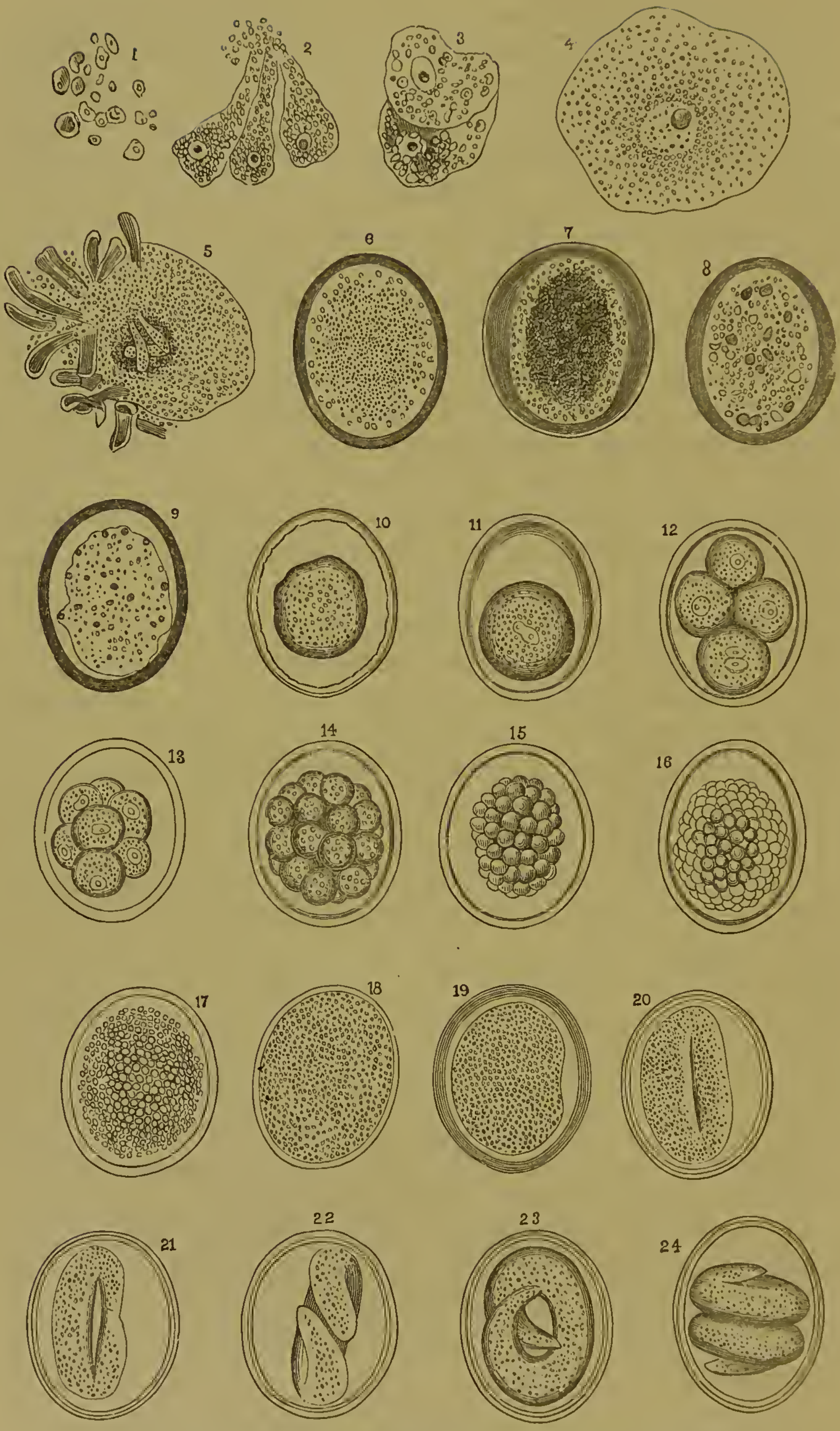

FIG. 49.—Germs and ova of *Acaris mystax*. Nos. 1 to 3 magnified 330 diameters and Nos. 4 to 24 magnified 220 diameters. After Nelson.

tinctly oval shape, the true yolk-membrane and the external chorional envelope now becoming more and more differentiated, until the latter acquires a regularly tuberculated surface. Co-ordinating with these changes the granular yolk is seen transforming itself into a single large embryonal cell; after a time this cell divides and subdivides by the ordinary process of yolk-segmentation, until it is finally resolved into the condition of a short, stout, vermiform embryo. The egg having assumed its definitive oval shape, the intrachorional embryo remains coiled within the shell, and does not make its escape until the egg has passed from the body of the parent worm.

Into the question of the mode of formation of the ovarian ova, and also into that of the development of the spermatozoa, I do not enter. However unwillingly, I must, in this matter, be contented to refer to Professor Allen Thomson's classical article ovum (quoted below), to Leuckart's elaborate analysis (l. c., Bd. ii, s. 76-92), and also, especially, to the exhaustive memoir of Claparède, whose brilliant labors, like those of Henry Nelson, were too early terminated by death. Shortly after graduation Nelson suffered a virtually enforced banishment from his native land.

Bibliography (No. 33).—*Bellingham, O. B.*, "On the Genus to which the Worms known as Ascarides belong," 'Dublin Journ.,' vol. xiv, 1839.—*Idem*, "Catalogue of Irish Entozoa," 'Ann. of Nat. Hist.,' vols. xiii and xiv, 1843-44; and in the first part of Charlesworth's 'Mag. of Nat. Hist.,' vol. iv, 1840. See also the address by Dr E. D. Mapother on the "Lives and Writings of O'Ferrall and Bellingham," in the 'Dubl. Journ. of Med. Sci.,' Nov., 1877, p. 471 *et seq.*—*Bischoff*, 'Widerlegung (u. s. w.),' Giessen, 1853; quoted by Claparède, l. c. *infra*, p. 9.—*Idem*, 'Bestätigung (u. s. w.),' Giessen, 1864.—*Idem*, "Ueber Ei- und Samenbildung und Befruchtung bei *Ascaris mystax*," Sieb. and Köll. 'Zeitsch.,' 1855, s. 377; also in S. and K. 'Zeitsch.,' 1856.—*Bremser*, 'Icones helminth.,' p. 23, tab. iv.—*Claparède, E.*, "Ueber Eibildung und Befruchtung bei den Nematoden," S. and K. 'Zeitsch.,' 1857, s. 106. —*Idem*, 'De la formation et de la fécondation des œufs chez les vers Nématodes,' Genève, 1859. See also 'Ann. of Nat. Hist.,' vol. i, 3rd series, 1858.—*Cobbold*, in 'Proceed. of the Zoological Soc. of London,' Nov., 1862.—*Idem*, 'Brit. Assoc. Rep.,' 1862.—*Idem*, "On the occurrence of *Ascaris mystax* in the Human Body," with figures, 'Lancet,' Jan., 1863; and in

the 'Dublin Med. Press,' Feb., 1863.—*Idem*, 'Entozoa,' chap. xi, p. 316, 1864.—*Idem*, 'Worms,' pp. 72 and 112, 1872.—*Idem*, in "Obituary Notice of Dr Henry Nelson," 'Med. Times and Gaz.,' 1865 (?).—*Davaine*, 'Traité,' l. c., 1877.—*Diesing, C. M.*, 'Syst. Helm.,' vol. ii, p. 180, 1850.—*Dujardin* (l. c., Bibl. No. 2), p. 162.—*Frœlich*, in 'Naturf.,' xxiv, s. 141 (*Asc. felis*). —*Funke, O.*, 'Lehrbuch (u. s. w.),' 1857, s. 1299.—*Gmelin*, 'Syst. Nat.,' p. 3031.—*Golze*, 'Naturg.,' l. c., s. 79.—*Gurlt*, 'Path. Anat.,' s. 366.—*Heller, A.*, "Darmschmarotzer," in 'Von Ziemssen's Handbuch,' Bd. vii, s. 361.—*Idem*, 'Sitzungsb. d. Erlanger phys.-med. Soc.,' 1872, s. 73.—*Hering*, "Ueber das Vorkommen und die Entwicklung der *Ascaris mystax* bei jungen Hunden," quoted by Leuckart from 'Würtemb. Naturw. Jahreshefte,' 1873, s. 305-337.—*Kölliker*, in 'Müller's Archiv,' 1843, s. 68 *et seq.*—*Leidy*, 'Proc. Acad. Phil.,' viii, p. 50.—*Leuckart*, l. c., Bd. ii, s. 258.—*Meissner, G.*, "Beobachtungen über das Eindringen der Samenelemente in den Dotter," S. and K. 'Zeitsch.,' 1854, s. 208.—*Morton, T.*, "Another Example of the Occurrence of *A. mystax*, from a Child of fourteen months old," in a letter to the 'Lancet,' March 11th, 1865, p. 278.—*Nelson, H.*, "On the Reproduction of *Ascaris mystax*," 'Proc. of the Royal Soc.,' in 'Philosoph. Trans.,' and in 'Med.-Chir. Rev.,' 1051-52; also in 'Froriep's Tagsbericht.,' 1852, s. 205-207.—*Rudolphi*, 'Synops.,' p. 42, 1819.—*Schneider*, "Ueber Bewegung an dem Samenkörperchen der Nematoden," in 'Monatsb. d. Berliner Akad.,' 1856, s. 192.—*Idem*, 'Monographie der Nematoden,' Erste Abth., s. 38, und Dritte Abth., s. 263 ("Entwicklungsgeschichte"), 1866.— *Siebold*, 'Vergleichende Anatomie,' 1848, s. 153, and in Burnett's edit., p. 125 *et seq.*, 1854.—*Thomson, A.*, art. "Ovum," in 'Todd's Cyclop. of Anat. and Phys.,' supp., 1859.—*Idem*, "Ueber die Samenkörperchen, die Eier und die Befruchtung der *Ascaris mystax*," S. and K. 'Zeitsch.,' 1856, s. 425.—*Idem*, "Report of Glasgow Meeting" ('Brit. Assoc. Rep.'), 1855, p. 158.

Ascaris maritima, Leuckart.—This is a well-marked species. Judging from the characters presented by the solitary, sexually-immature female which supplied Leuckart with his only means of diagnosis, this worm may be briefly described as a filariform nematode about $\frac{3}{4}''$ in length and about $\frac{1}{25}''$ in breadth. Although there are no cephalic aliform membranes, the cuticle immediately below the lips forms small and distinct projections,

one on either side of the head ('Die Mensch. Par.,' Bd. ii, s. 877).

This entozoon was discovered by Dr Pfaff at Jacobshavn, near Godhavn, West Greenland, in April, 1865. Two years later he sent the specimen to Krabbe, who afterwards transmitted it to Leuckart. In the original communication addressed to the Copenhagen helminthologist, Dr Pfaff states that he procured the worm from amongst matters vomited by a child, and he incidentally observes that he had hitherto encountered only *Bothriocephalus cordatus* and *Oxyuris vermicularis* amongst Greenlanders. As to the source of infection, Prof. Leuckart not unnaturally refers to the similar conditions of existence shared by the human and carnivorous inhabitants of that country. It is well known that bears, polar-bears, seals, and walruses are largely infested by nematodes (*Asc. transfuga, A. osculata, Ophiostoma dispar*, &c.), but these various species are quite distinct from Dr Pfaff's little "spulwurm."

Ascaris lumbricoides, Linneus.—This common parasite was for a long while regarded as identical with the great lumbricoid of the horse, but the question has been finally settled by Schneider, who has shown that the human worm, although identical with Dujardin's *Ascaris suilla* of the hog, is nevertheless quite distinct from the *Ascaris megalocephala* of solipeds. The large lumbricoid occasionally found in the ox belongs to the human worm. Our large human helminth resembles the common earth-worm in general appearance only. The males usually measure from four to six inches in length, and the females from ten to fourteen inches. Some have been reported up to seventeen or eighteen inches in length. The body is smooth, fusiform, and elastic, and marked by numerous fine transverse rings. It is attenuated towards either extremity, the anterior end terminating in a prominently three-lobed mouth. The tail is bluntly pointed. The female is much shorter than the male, having a diameter of nearly a quarter of an inch. The male is supplied with a double spiculum, its tail being always more or less curved towards the central surface. The female reproductive orifice is situated above the centre of the body. According to Schneider, the tail supports from 138 to 150 caudal papillæ, that is, from 69 to 75 on either side of the median line. Below the anus the papillæ are regularly arranged in pairs, seven in number, the two uppermost pairs being double.

Notwithstanding the advantage which the size of this entozoon affords us in the matter of observation and experiment, we are yet ignorant as to the precise mode in which the young gain access to the human body. From what has been said respecting the quick growth of *Ascaris mystax* in the dog, and from what has been observed respecting the rapid growth of the so-called *A. suilla* in the hog, we know that the worm requires but a short time to pass from the larval to the sexual state. The view of Hering, Mosler, Davaine, and others, who suppose that these worms are reared in a direct manner by swallowing the ova, is, as Leuckart observed, not yet proved. We are not in full possession of the facts of larval development. It is true that Professor Heller's interesting "find" has shown that when these worms first gain access to the human body their size is quite insignificant. At the post mortem of an imbecile, Heller discovered eighteen young worms, varying in size from about $\frac{1}{9}''$ to $\frac{1}{2}''$ in length (2·75 to 13 mm.). The sexes were indistinguishable. As a set-off against this, Leuckart's repeated attempts to rear *Ascaris lumbricoides* and *A. mystax* by means of direct feeding-experiments with the eggs all failed. Thus, we are yet left in doubt as to the destiny of the larvæ during the period which elapses between the time of their escape from the egg and the time of their entry into the human body. So important is the question as to the mode of origination, growth, and subsequent development of the larvæ, that it may be well to trace, however briefly, what steps have been taken to clear up the matter. Leuckart obtained his negative results by the administration of ripe ova to dogs, rabbits, swine, and mice. The eggs of *Ascaris lumbricoides* have been kept alive by Dr Davaine for a period of more than five years. I have myself watched the development of their contents in fresh water through all the stages of yolk-segmentation up to the stage of an imperfectly-organised, coiled, intra-chorional embryo, and have kept them in the latter condition for a period of three months. According to Davaine ('Comptes Rendus,' 1858, p. 1217), the fully-developed embryo is cylindrical, its length being $\frac{1}{100}$th of an inch. The mouth is not furnished with the three characteristic papillæ of the genus, and the tail terminates suddenly in a point. Davaine administered some of his five-year-old embryos to rats, and had the satisfaction of finding a few of these eggs in the rodent's fæces, with their embryos still living, but striving to emerge. He also gave eggs to a cow, and intro-

duced others into the stomachs of dogs in small linen-covered flasks. As a general result it may be said that the embryos escaped from their shells. Those eggs, however, in which the yolk-segmentation had not arrived at the early embryonal stage remained unaffected. According to Heller, the embryo of *A. lumbricoides* casts its first skin while still within the egg, and " a subsequent ecdysis probably completes its definitive form " (l. c., s. 615). So far back as 1853 Verloren reared coiled intra-chorional embryos in the eggs of *Ascaris marginata* within a period of fifteen days in distilled water. I also reared the embryos of this species in fresh water, and kept them alive for a period of nearly a year and a half, at the expiration of which time, and during the warm weather, some few of them succeeded in making their escape. According to Davaine, the eggs of many nematode species will readily retain their vitality though long exposed to dryness, but their yolk-contents will not go on developing during this period of exposure. As regards *A. mystax,* however, Heller remarks that whilst " the eggs have a great power of resisting external influences, their development is not arrested in spirits of wine, chromic acid, or oil of turpentine " (l. c., s. 631). In the case of *Ascaris tetraptera* of the mouse, embryonic formation goes on in spite of the absence of external moisture. Davaine has noticed the same thing in the oxyurides of rodents. Dryness does not even destroy the eggs of *A. lumbricoides* and *Tricocephalus dispar.* It would seem, in short, that the eggs of nematodes which normally take up their residence in cats, dogs, and in the carnivora which reside in arid regions, will develop embryos in the egg without external moisture. As before remarked, Davaine thinks it is not necessary that these nematode embryos should pass through any intermediary bearer, and he believes that they are often directly transferred to the stomach of their " hosts " whilst adhering in the form of an impalpable dust to the coats of their bearers, whence they are detached by the animal's frequent habit of licking the fur. Davaine's view has received some support from the observations and experiments of Unterberger with the eggs of *Ascaris maculosa.* This observer administered eggs of the worm to doves (whose fæces were free of eggs), and seventeen days after found ova in the fæces.

With the eggs of the *Ascaris megalocephala* of the horse I performed numerous experiments. I reared the embryos in

simple fresh water, and found them during warm weather escaping before the expiration of five months. I also succeeded in rearing these larvæ in pond mud, noticing, at the same time, that after their escape from the shell they grew more or less rapidly up to a certain point, after which they ceased growing. The addition of horses' dung to soft wet mud in one case, and of cows' dung in another, neither appeared to advance nor retard the process of embryonal formation, so long as the embryos were enclosed in their shells. On the other hand, when I reared embryos in simple horse-dung purposely kept moist, they attained a higher degree of organisation than did those in wet mud or water. Having watched hundreds of these larvæ under varying conditions, I came to the conclusion that, after escape from the egg, their activity, growth, and strength was most marked when they occupied media which happened to be impure. Davaine experimented on cows, and Leuckart also experimented on horses, with the eggs of this worm without success. Leuckart also failed to rear the larvæ in intermediary hosts. Some eggs passed through the water-palmer unaltered.

These results, so far as they go, seem to be borne out by facts of a professional order. Thus, an instance has been brought under my notice where a considerable number of peasants and their children, dwelling in a parish in Yorkshire, were infested with this worm. There was, in short, a local endemic helminthiasis. Through the parish runs a stream which supplies the cottagers with all the water they employ for domestic purposes (washing, drinking, and so forth). Some of the peasants living by the side of the stream keep pigs, and the sewage from this source has been allowed to pass into the stream itself. Now, if Schneider's determination as to the identity of the lumbricoid of man and the pig is correct (which I do not doubt), the explanation of the cause of the endemic becomes a very simple matter. But it does not explain all that we desire to know about the young worms. Either the freed embryos before they enter the human bearer accomplish further changes of form and growth in the sewage or impure water; or, what is far less probable, they pass into the bodies of intermediary hosts (such as insect-larvæ, Gammari, Entomostraca, &c.) to undergo the necessary changes. Practically, no doubt, it comes to the same thing in the end. Even if we suppose that the *Ascaris suilla* and *A. lumbricoides* are not

identical species, still it is evident that any person discharging the eggs of lumbricoids in the vicinity of open waters becomes, by that fact, a source and centre of infection. To ensure an endemic it is probably only further necessary that the human inhabitants should employ the contaminated water for domestic purposes. But time and an increase of temperature must be allowed for the bringing about of those known and unknown larval changes that alike form the necessary antecedents of infection. In this connection I will only add, that if the present position of the question be such as I have here represented it to be, we see that Mosler was not far wrong when he suggested that "contamination of the drinking water with the eggs out of privies is to be blamed" as a source of infection. According to Heller, from whom I quote, Mosler actually demonstrated the presence of the eggs in water thus exposed. In like manner it becomes obvious that Davaine's practical remark (although it was based on the assumption of a direct infection by the eggs), that filtration will probably be sufficient to prevent infection, loses nothing of its hygienic value.

The foregoing observations naturally lead one to the question of frequency and distribution. Davaine holds that the comparative infrequency of this parasite in Paris is due to the free use of the filter. In London, though not uncommon, the worm rarely occurs in great numbers in one bearer. Those cases in our hospitals, where considerable numbers have been present, have usually come up from suburban or country places. Heller states that these worms were found in 9·1 per cent. of post mortems conducted at Dresden, in 12 per cent. at Erlangen, and in 17 per cent. at Kiel. He quotes Huss as stating that no one is free from this worm in Finland. The prevalence of large round worms in warm countries generally is well known. Throughout India and the East they are extremely abundant, and the same may be said of the West Indies, Brazil, and the adjacent territories. Professor Dyce and others have remarked on the extreme prevalence of lumbrici in the Mauritius, but they are comparatively rare along the sea border. In all situations where there is an abundant fresh-water supply these parasites are particularly common, as in the lowlands of Holland and the lake districts of Sweden. The abundance of water is certainly not alone sufficient to explain the frequency of the parasite, seeing that the most important factor is that which rests upon the uncivilised habits of the rural population.

What, therefore, it may be asked, can be the cause of immunity enjoyed by Icelanders in this respect? The answer is not apparent; nevertheless Krabbe and Finsen have testified to the fact that Iceland is the only country that is entirely free from *Ascaris lumbricoides*.

As remarked in my previous work the number of worms present in any human bearer is usually small, varying commonly from one to six or eight. Cases in which scores or hundreds have existed are comparatively rare. Küchenmeister mentions the case of one child who passed 103 examples, and of another child that harbored from 300 to 400 worms. Dr Gilli, of Turin, gives a case where 510 were passed by a child, and Cruveilhier estimated that over 1000 existed in an idiot girl, whose intestines he found crammed with them. A remarkable case has also been communicated to me by Dr Mackeith, of Sandhurst, Kent, who, by means of santonine, expelled from a little girl, five and a half years of age, 300 lumbrici; and I am likewise indebted to Dr Cooper Rose for notes of a case in which about thirty lumbrici were expelled, chiefly in consequence of the employment of this drug. The most interesting fact, however, in this case was that the child was only fifteen months old. In this case the symptoms were severe.

The proper habitat of the lumbricus is the upper and middle part of the small intestine. From this situation it often wanders into the stomach, and frequently gains access to the outer world, not only by the natural passages of the mouth, nostrils, and anus, but also, occasionally, in a more direct way, by perforating the intestinal and abdominal walls. Many cases are on record where lumbrici have passed into the abdominal cavity. In other instances they have lodged themselves within the abdominal viscera and pulmonary organs. When they find their way into the parietes of the abdomen and adjacent parts, they usually give rise to the formation of abscesses requiring surgical interference.

As regards the symptoms produced by lumbrici, these vary according to the situation they happen to occupy. The symptoms are also modified by age and temperament. In the stomach and intestines they give rise to colic and shooting pains about the abdomen, followed generally by dyspepsia, nasal itching, nausea, vomiting, and even diarrhœa. Occasionally death supervenes suddenly. A singular case of this kind (the particulars of which I only gathered from a local newspaper) occurred in a boy, thirteen years of age, at the County Gaol at Hertford,

in 1873. From Dr Evans's statement, made at the coroner's inquest, the sole cause of death appeared to be due to pressure on the windpipe by a worm lodged in the gullet. Sometimes there is cerebral disturbance, attended with general restlessness and convulsive twitchings during sleep. Thus, Dr Woodman has recorded a serious case of convulsions arising from lumbricoid worms, in which, however, a cure was effected by expulsion of the worms. An anonymous writer in the 'Medical Gazette' records a case of epilepsy from this cause, whilst another writer in the same journal (1839) mentions an instance where two lumbrici and one tapeworm were associated in the production of similar phenomena. But a much more striking case is also given (anonymously) in the 'Gazette' for 1874 (p. 415), where a single lumbricus caused the bearer to be a lunatic for eight years. The victim suffered from cataleptic fits, which lasted for two or three weeks at a time. M. Petrequin, in his 'Traité Pratique,' records two cases of amaurosis in young girls produced by lumbrici. A fatal case is recorded by Petrenz, where 200 worms produced enteritis, and another fatal case is given by Roger from perforation (1848). Cases of perforation are also given by Young, by Blair (1861), by Mondière (1839), by Buchner (1851), by Sheppard (1861), and by Luschka (1854), the worms in this last-mentioned case occupying the cavity of the pleura. Cases of severe irritation affecting the genito-urinary organs are given by Dreyfus, Buckingham, and others; and one or two instances are reported where these worms have been discharged from several parts of the body (Neilson, 1833). I may add that the third fasciculus of a work illustrating the collection of morbid anatomy in the Army Medical Museum at Chatham gives a case of lumbrici occupying the biliary ducts and gall-bladder. I find, moreover, two additional cases of perforation of the small intestine, one of which appeared in the 'London Medical Gazette' (1827) and the other in the 'Lancet' (1836).

During the Franco-German war Dr Reginald Pierson, as he afterwards informed me, removed a lumbricus from an abscess formed in the abdominal parietes of a soldier. But amongst the most curious cases (illustrating the wandering habits of these parasites) are those severally described by Barwell (1857), Williams, Prichard, and the Messrs Stockbridge. In Barwell's case an Ascaris was expelled from a child who had swallowed the brass "eye" of a lady's dress. Through the circular loop of

this eye, used as a toy, the Ascaris had partly thrust its body, and becoming thus strangulated, it probably perished before it was evacuated. In Prichard's case (1859) one or two lumbrici had similarly trapped themselves in the eyes of buttons swallowed by the patient, and one worm, not contented with a single strangulation, had succeeded in passing its body through two buttons. In 1842 Mr T. G. Stockbridge gave a similar case, in which he, not inaptly, spoke of these "hooks and eyes" as constituting a new remedy or "worm-trap" for lumbricus, and singularly enough, a namesake (W. Stockbridge), in the succeeding year, also recorded a like instance of the "mechanical expulsion of worms" by metallic buttons. Again, a third correspondent in the 'Boston Journal,' under the initials A. M., spoke of an open-topped thimble as constituting another new "worm-trap," whilst he gave a case of lumbrici penetrating "metallic suspensor buttons." There is also the case reported by Williams, who, at a meeting of the Boston Society for Medical Improvement, exhibited "a lumbricus with a dress-hook attached" (1857). Lastly, another lumbricus, trapped in the same way, may be seen in the Museum of the Royal College of Surgeons at Edinburgh.

Owing to the presence of a peculiar irritating vapour which is given out by these lumbricoids, particularly when fresh, several observers have experienced curious symptoms. Thus, Miram on two occasions, when examining *A. megalocephala*, was attacked with sneezing, excessive secretion of tears, with swelling of the puncta lacrymalia, and Huber also experienced a troublesome itching of the hands and neck after examining specimens of *A. lumbricoides*. In like manner I have myself had watery suffusion of the eyes (when collecting the perivisceral fluid for Marcet's analyses: see Bibliog.), and Bastian has given a detailed account of the serious effects which the poison produced upon him. In Bastian's case even spirit specimens produced irritation. The attacks of catarrh and asthma were so persistent and severe that they lasted for six weeks at a time. So sensitive was Bastian to the lumbricoid-miasm that he could not even put on a coat that he had worn during his investigations without experiencing fresh attacks of sneezing and other catarrhal symptoms. The attacks became periodical, occurring between five and six in the morning, being accompanied by dyspnœa and a distressing spasmodic cough. Bastian, in short, was quite a martyr in the cause of nematode anatomy.

Bibliography (No. 34).—*Aboussson, L.,* "On the Presence of Worms (lumbrici) in the Air-passages," from 'Arch. Gén. de Méd.,' in 'Med.-Chir. Rev.,' 1836.—(Anonymous), *A. M.,* "Another New Worm-trap—an open-topped Thimble in the Nostril (also notice of metallic suspender buttons penetrated by Lumbrici)," 'Bost. Med. and Surg. Journ.,' vol. xxvii, p. 121, 1842-43; see also T. G. and W. Stockbridge.—(Anon.), "Lumbrici expelled by Bismuth," 'Bost. M. and S. Journ.' (from 'Gaz. des Hôp.,' 'Journ. des Connaiss. Méd.,' and 'Boletin del Inst.-Med.-Valenc.'), 1859.—(Anon.), "Case of one Tapeworm and two Lumbrici causing Epilepsy," from 'Bull. du Midi' and 'Gaz. Méd.,' 1839.—(Anon.), "Case of Perforation of the Ileum by Ascarides," from 'Hufl. and Ossan's Journ.,' in the 'Lancet,' 1836.—(Anon.), "Case of Lumbrici in the Biliary the Ducts and Gall-bladder," note and fig. in third fasc., illust. the Coll. of Morb. Anat. in the Army Med. Mus. at Chatham, 1838. —(Anon.), "A Lumbricus causing Catalepsy, with Fits lasting two or three weeks; Cure by Vomiting," 'Lond. Med. Gaz.,' 1847, p. 415.—*Archer, E.,* "On a Case of *A. lumbricoides* producing alarming symptoms," 'Lancet,' 1857.—*Barwell,* "Case of Ascaris expelled by the swallowing of a foreign body," 'Lancet,' 1857.—*Bastian, H. C.,* "On the Anatomy and Physiology of the Nematoids, Parasitic and Free," 'Phil. Trans.,' 1866, p. 545; for the account of his poison-symptoms, see *foot-note,* p. 583.—*Batterbury, R. L.,* "Jaundice due to the presence of Lumbrici," 'British Med. Journ.,' Nov., 1878, p. 721.—*Bigelow, H.,* "Worm in an Abscess," 'Bost. Med. and Surg. Journ.,' vol. xxxiii, p. 486, 1836.—*Blatchley, C. C.,* "Two Cases of *A. lumbricoides,* attended with Abscesses, followed by large purulent discharges, and Worms therein," 'New York Med. and Phys. Journ.,' vol. i, new series, p. 209, 1829.—*Bonfils, E.,* "Lesions and Path. Phenomena caused by Lumbrici in the Biliary Ducts," from 'Arch. Gén.,' in 'Brit. and For. Med.-Chir. Rev.,' 1858, and in 'Amer. Journ. of Med. Sci.,' vol. xxxvii, 1859.—*Bradford, J. T.,* "Singular Case of Worms (Lumbrici)," 'Bost. Med. and Surg. Journ.,' vol. xxviii, 1843. *Brigham, A.,* "Worms in the Bladder simulating 'Stone,'" 'Amer. Journ. Med. Sci.,' 1837; 'Med.-Chir. Rev.,' 1837; 'Quart. Journ. Calcutta Med. and Phys. Soc.,' vol. ii, p. 132, 1838.—*Buchner,* "On the Perforation of the Intestinal Canal by Worms (with ref. to two cases)," from 'Med. Zeitung,' 1850, in 'Med.-Chir. Rev.,' 1851.—*Calderwood,* "Treatment," 'Brit.

Med. Journ.,' Jan. 30, 1875.—*Chapman, N.*, "Case of 68 Ascarides causing Pulmonary Disease," in his 'Dis. of the Thoracic and Abd. Viscera,' p. 263, and in 'Med.-Chir. Rev.,' 1845.—*Chiaje, Delle-*, in 'Rend. dell' Accad. di Napoli,' 1846 ("Anat.," p. 403).—*Church, J.*, "On *A. lumbricoides*," 'Mem. Med. Soc. Lond.,' vol. ii, 1789.—*Claparède* (l. c., Bibl. No. 33, for development).—*Clark, P.*, "Discharge of a Lumbricus through the Male Urethra," 'New York Journ. Med.,' 1844, rep. in 'Lancet,' 1844, and in 'Edin. M. and S. Journ.,' vol. lxiv, 1845.—*Cloquet*, 'Anat. des vers Intest.,' 1824.—*Cobbold*, "On Sewage and Parasites, especially in relation to the Dispersion and Vitality of the Germs of Entozoa," 'Med. Times and Gaz.,' Feb. 25, 1871, p. 215.—*Idem*, 'Entoz.,' p. 302-315. —*Idem*, 'Worms,' lect. xvi, p. 3.—*Idem*, art. "Ascaridæ," in 'Maunder's Treasury,' 1862.—*Colvan, J.*, "Case in which Eleven Round Worms of the species *A. lumbricoides* were removed by Anthelmintics," 'Dubl. Med. Press,' vol. xxvi, p. 211, 1851.—*Cutler, J. H.*, "Death by Worms (a large Lumbricus being found in the Wind-pipe)," 'Bost. Med. and Surg. Journ.,' vol. lxvi, p. 392, 1862.—*Czermak*, in 'Sitz. d. k. Akad. d. Wissensch.,' 1852 ("Anat.," s. 755).—*Davaine*, in his 'Traité,' l. c., 2nd edit., syn. xcvii, and p. 122-235 (with details of forty-five cases); see also his memoir "On the Development and Propagation of the *Trichoceph. dispar* and *A. lumbricoides*," from 'Comptes Rendus,' in 'Ann. Nat. Hist.,' vol. ii, 3rd series, 1858; also in the 'Journ. of Pract. Med. and Surg.,' Eng. edit., vol. i, 1858, and in the 'Veterinarian,' vol. xxxii, p. 700, 1859, from 'Proc. of Acad. des Sci.,' in 'Bost. M. and S. Journ.,' vol. lix, p. 157, 1858-59.—*Idem*, art. "Entozoaires," in 'Dict. de Méd. et Chir. prat.'—*David, J. B.*, "Cases of Perforation of the Intestines by Worms," from 'Gaz. Méd. de Paris,' in 'Dubl. Med. Press,' 1840, p. 223.—*Diesing*, 'Syst. Helm.,' ii, p. 166; and in 'Revis der Nemat.,' l. c., s. 660.—*Douglas, J.*, "Worms (Lumbrici) evacuated at an Ulcer of the Groin," 'Med. Ess. and Obs.,' vol. i, 2nd edit. (vol. i, 5th edit., p. 179), p. 222, 1737.—*Dowler, B.*, "Case of Worms in the Urinary Bladder," from 'New Orl. M. and S. Journ.,' in 'New York Journ. Med.,' new series, vol. xiv, 1855.—*Dubini*, 'Entozoografia umana' ("Anat.," p. 148).—*Dupuytren*, "Lumbricus passed by the Urethra," from "Clin. Lect.," in 'Lond. Med. and Surg. Journ.,' 1846, p. 14.—*Dyce, R.*, "On Lumbrici and the Causes of their Prevalence in the Mauritius," 'Lond. Med. Gaz.,' 1834.—*Evans*,

T., "Lumbricus causing Death," rep. of coroner's inquest in the 'Herts Advertiser and St Alban's Times' for Feb. 8, 1873. *Gervais* (and *Van Beneden*), 'Zool. Med.,' ii, p. 118.—*Gilli*, "Account of a Case in which 510 Worms (Lumbrici) were voided by a Child," from 'Giorn. d. Scienze Med. di Torino,' in 'Med.-Chir. Rev.,' 1843.—*Goopta, G. D. D.*, "On Suicide and Lumbrici," 'Ind. Med. Gaz.,' July, 1874, and 'Lond. Med. Rec.,' Aug., 1874, p. 502.—*Heller, A.*, "Darmschmarotzer," in 'Von Ziemssen's Handb.,' s. 612-631.—*Holland, G. C.*, 'A peculiar Case of Nervous Disease or Derangement of the Nervous System (associated with *A. lumbricoides*),' 'Edin. M. and S. Journ.,' vol. lxiii, 1845.—*Howall*, "Abscess of the Groin, with discharge of Lumbrici," 'Lond. Med. Gaz.,' 1845, and 'Edin. M. and S. Journ.,' 1846, p. 241.—*Johnson, W. G.*, "Case of forty Lumbrici in a Boy who died with Traumatic Tetanus," "Rep. of South Mid. Br. of Brit. Med. Assoc.," in 'Brit. Med. Journ.,' 1858.—*Kell*, "Perforation of the Intestines by a Worm," 'Lond. Med. Gaz.,' 1828.—*Kilgour, T.*, "Case in which Worms in the Nose, productive of alarming Symptoms, were removed by the Use of Tobacco," 'Med. Comment.,' vol. viii, 1783.—*Kirkland*, "Case of Lumbricus in an Abscess of the Liver," rep. in his book, entitled 'An Enquiry,' vol. ii, p. 186 (quoted by Richter and Davaine), London, 1786.—*Küchenmeister*, 'Manual,' Eng. edit., p. 410-427.—*Leidy, J.*, 'Proc. Acad. Phil.,' 1856, p. 50.—*Lente, F. D.*, "Lumbricus in the Stomach causing Dyspnœa," in his "Rep. of Cases occurring in the New York Hosp.," in 'New York Journ. of Med.,' vol. v, new series, p. 167, 1850.—*Lettsom*, 'Case of Lumbricus evacuated from an Abdominal Abscess," 'Trans. Med. Soc. Lond.,' and 'Lond. Med. Repos.,' 1817.—*Leuckart*, l. c., s. 152-258.—*Lieberkühn*, in 'Miller's Arch.' ("Anat. of *A. suilla*"), 1855, s. 331.—*Luschka*, "Case of Lumbrici within the Pleura," from 'Virch. Arch.,' in 'Med.-Chir. Rev.,' 1854.—*Lowne, B. T.*, "The Anatomy of the Round Worm," 'Trans. Roy. Micr. Soc.,' 1871, p. 55.—*Maesson*, "On a Worm found in the Bubo of a Woman 36 years of age;" see 'Entozoa and Parasites, being a ref. to numerous papers;' from "Valentin's Repertorium," in 'Month. Journ. of Med. Sci.,' vol. ii, p. 559, 1842; also in 'Micr. Journ. and Struct. Rec.,' p. 85, 1842.—*Marcet, W.*, "Chemical Exam. of the Fluid from the Peritoneal Cavity of *A. megalocephala*," 'Proc. Roy. Soc.,' 1862, No. 72, p. 69.—*Martin, D. T.*, "Large number of Worms (140 examples of

A. lumbricoides) discharged from a Child five years old," rep. from the "Stethoscope," in 'Bost. Med. and Surg. Journ.,' vol. xliv, p. 301, 1851.—*Mattei, R.*, "On a Case of two Lumbricoid Worms, which had penetrated during life into the liver, and were demonstrated by Prof. G. Pelizzari to his pupils in the Sch. of Path. Anat. of Florence," from 'Gaz. Med. Ital. Toscana,' in 'Dubl. Quart. Journ.,' vol. xxiv, 1857.—*Michel*, "Case of Epilepsy in a Girl ten years of age, caused by Lumbrici," from 'Journ. des Connaiss. Méd.,' in 'Amer. Journ. of Med. Sci.,' vol. vi, p. 451, 1843.—*M'Laggan, J.*, "Gangrenous Sore from a large Worm in the Parietes of the Abdomen," 'Med. Comment.,' vol. ii, 1774, p. 80.—*Molin*, in 'Sitzungsb. d. k. Akad.,' 1859, s. 23.—*Mondière*, "On Perforation by Worms (three cases)," from 'L'Expérience,' in 'Med.-Chir. Rev.,' 1839.—*Moore, E. D.*, "Example of *A. lumbr.* ejected by the Mouth," 'Prov. Med. and Surg. Journ.,' 1852.—*Morgan, J.*, "Case of Perforation of the Stomach, probably by a (Lumbricus) Worm," 'Lancet,' 1836.—*Morland, W. W.*, "Ejection of numerous Lumbrici from the Mouth, impaction of the small intestine with Lumbrici, of which 365 were removed post mortem)," 'Bost. M. and S. Journ.,' vol. lvi, 1857.—*Idem*, an "*A. lumbr.* of unusual size (over 17 inches long)," 'Rep. of Bost. Soc. for Improv.,' in 'Bost. M. and S. Journ.,' vol. lviii, p. 62, 1858.—*Neilson*, "Discharge of Worms from various parts of the Body," 'Med.-Chir. Rev.,' and 'Lond. Med. Gaz.,' 1833.—*Omond, R.*, "Case of Lumbricus attended with Hæmoptysis," 'Edin. Med. Journ.,' 1856.—*Owen, R.*, art. "Entozoa," l. c.—*Padley, G.*, "Jaundice and Lumbrici," 'British Med. Journ.,' Dec. 14, 1878, p. 877.—*Petrenz*, "Case of fatal Enteritis produced by (200) Lumbrici," from 'Clarus and Radius' Beitr. zur Pract. Heilk.,' in 'Dubl. Journ.,' vol. xi, 1837; also in 'Lond. Med. Gaz.,' 1837.—*Playfair*, "Case of Lumbricus (69 specimens) cured by the Mudar," 'Calc. Med. and Phys. Soc. Trans.,' vol. ii, p. 407, 1826.—*Pomeroy, C. G.*, "Escape of Worms (17 Lumbrici) from the Navel of a Child," 'Bost. M. and S. Journ.,' vol. xxi, 1840.—*Prichard, A.*, "Case of Lumbricus," 'Rep. of East York and North Lincoln Br. of Brit. Med. Assoc.,' in 'Brit. Med. Journ.,' 1859.—*Royer*, "Case of Intestinal Perforation by a Lumbricus," report in 'Lancet,' 1856.—*Rumsey, N.*, "Cases of Lumbricus and Tænia associated with Hæmoptysis," 'Med.-Chir. Trans.,' 1818.—*Sandwith, H.*, "Remarks on Worms in the Peritoneal Cavity, with a case," 'Brit. Med. Journ.,' 1861.—*Schleifer*,

"Case of a Deaf and Dumb Child restored after the discharge of Worms (87 Lumbrici and innumerable Oxyurides)," from 'Œsterr. Med. Wochensch.,' in 'Amer. Journ. of Med. Sci.,' vol. viii, p. 473, 1844.—*Schneider, A.*, 'Monog der Nemat.,' s. 36.—*Idem*, "On the Nervous System of Nematoda," from the German by *Busk*, 'Quart. Journ. Micr. Sci.,' 1863.—*Schultze*, "Case of Stuttering occasioned by Worms," from 'Med. Zeit.,' in 'Med.-Chir. Rev.,' 1837.—*Sheppard*, "Case of *A. lumbr.* extracted from an Abdominal Abscess," 'Brit. Med. Journ.,' 1861.—*Smith, J. N.*, "Thirty-nine Specimens of *Ascaris lumbricoides* in a Child," 'Bost. M. and S. Journ.,' 1856.—*Spalding, P.*, "Case of Worms (100 Lumbrici), *ibid.*, 1839.—*Stockbridge, T. G.*, "Worm-trap (hooks and eyes), a New Remedy," *ibid.*, vol. xxvii, p. 73, 1842-43; see also Anon., A. M.—*Stockbridge, W.*, "Mechanical Expulsion of Worms (by metallic buttons)," *ibid.*, vol. xxviii, p. 419, 1843.—*Van Beneden*, 'Animal Parasites,' l. c., p. 95; see also *Gervais*.—*Villemin*, "Case of Death from Worms (about 18 specimens of *A. lumbr.*), from 'L'Union Méd.,' in the 'Lancet,' and rep. in 'Dubl. Med. Press,' vol. xxxv, p. 327, 1856.—*Weinland*, in his 'Essay,' l. c., p. 88, and in 'Troschel's Arch.,' 1859, s. 283.—*Welsh, T.*, "Curious Facts respecting (symptoms produced by) Worms (*A. lumbricoides*)," art. ix in the 'Med. Papers communicated to the Massachus. Med. Soc.,' vol. i, p. 87, 1790.—*Wendelboe*, "Case of discharge of Worms (Ascarides ?) through the Skin," from 'Rep. of Roy. Soc. Copenhagen,' in 'Lancet,' 1836; see also *Neilson*.—*Williams, H. W.*, "Exhibition of a Lumbricus with a dress-hook attached," 'Rep. of Bost. Soc. for Med. Improv.,' in 'Bost. M. and S. Journ.,' vol. lvi, p. 163, 1857.—*Wilson, J.*, "On the prevalence of Lumbrici in China," in his 'Med. Notes on China,' London, 1846.—*Woodman, W. B.*, "Case of Convulsions, &c., arising from Lumbricoid Worms," 'Med. Times and Gaz.,' 1863.—*Young, W.*, "Cases in which Lumbrici were evacuated by Ulceration through the Parietes of the Abdomen," 'Lond. Med. Gaz.,' from 'Glasgow Med. Journ.,' 1828; rep. in 'Lond. Med. and Surg. Journ.,' vol. i, p. 564, 1828.

SECTION IV.—Part I. Acanthocephala (Thornheaded worms).

Echinorhynchus gigas, Goeze.—There is but one recorded instance of the occurrence of this entozoon in the human body. This is the oft-quoted case by Lambl, given in the 'Prager Vierteljahrschrift' for 1859. Lambl, indeed, described it as a separate species (*E. hominis*), but as the worm was a sexually-immature female, its identification with *E. gigas*, notwithstanding Schneider's great authority, can hardly be regarded as absolutely certain. The worm was found in the small intestine of a boy of nine years, and measured only rather more than the fifth of an inch in length. As Leuckart hints, the worm may be *Echinorhynchus angustatus*, or possibly the *E. spirula*, a species found in various South American apes (*Cebus* and *Jacchus*), and also in the Barbary ape (*Inuus*).

In 1872, Welch, unaware of Lambl's case, announced the discovery of "the presence of an encysted Echinorhynchus in man." The minute parasite found by him occurred in a soldier, thirty-four years of age, who died at Netley, but who had contracted the worm in India. "It was situated in the jejunum, immediately beneath the mucous coat, and formed an oval prominence in the interior of the gut." Speaking with great confidence, this able microscopist further remarks:—"The character and arrangement of the hooklets unequivocally shadowed forth a species of Echinorhynchus for the first time discovered as a representative of the Acanthocephala in the human body." Along with his elaborate description Welch gives several figures; but these, so far from producing conviction as to the accuracy of his inferences, have unfortunately led me to believe that the parasite in question would be more properly referred to the *Pentastomidæ*. But for Heller's acquiescence I might have more fittingly noticed this worm elsewhere. Davaine falls into the same view, and moreover accepts Lewis's "Echinorhynque du Chien," which I have shown to be a nematode (*Cheiracanthus robustus*). It is thus that serious errors creep into the literature of parasitism.

In the adult state the female *Echinorhynchus gigas* is a huge species, occasionally reaching two feet in length, with a breadth of one third of an inch. The male rarely exceeds three inches. This worm is common in swine, both wild and

domesticated. According to Schneider the embryos take up their residence in the grubs or larvæ of the cockchafer (*Melolontha vulgaris*), a discovery which very readily explains the manner in which hogs become infested. Whether *E. gigas* be a human parasite or not, it is certainly very injurious, not to say destructive, to swine. Although this parasite must be quite common in England I have experienced great difficulty in procuring specimens. In the second book of this work I shall give some interesting particulars furnished by the memoir of Prof. Verrill and privately by Mr George Wilkins. (See 'Parasites of the Pachydermata'.)

Bibliography (No. 35).—*Blanchard*, in 'Cuvier's Règne Animal,' tab. 35 (good fig.), and in 'Ann. d. Sci. Nat.,' ser. xii. —*Bremser*, 'Icones,' tab. vi.—*Cobbold*, "Parasites of the Hog," the 'Veterinarian,' 1875.—*Idem*, 'Manual,' l. c., p. 123.—*Davaine*, l. c., 'Syn.,' p. 83.—*Diesing*, l. c., ii, p. 2.—*Dujardin*, l. c., p. 503.—*Goeze*, l. c., s. 143 (good figs.).—*Gurlt*, l. c., s. 367.—*Heller*, 'Darmschmarotzer,' l. c., s. 663.—*Lambl*, l. c., *sypra*, Feb., 1859.—*Leuckart*, l. c., Bd. ii, s. 729; also in 'Bibl. Univ.' for March, 1863, and in 'Ann. Nat. Hist.,' vol. xii, 1863. —*Owen*, l. c., in 'Todd's Cyclop.' (figs. after Cloquet).—*Rudolphi*, 'Synops.,' pp. 63 and 310.—*Schneider*, in 'Arch. f. Anat. und Phys.,' 1868.—*Idem*, in 'Sitzungsb. der Oberhess. Gesellsch. f. Nat.,' &c., 1874 (quoted by Leuckart); see also 'Ann. Nat. Hist.,' 4th series, vol. vii, p. 441, 1871.—*Verrill*, 'The external and internal Parasites,' &c., l. c., p. 109.—*Welch*, "The presence of an Encysted Echinorhynchus in Man," 'Lancet,' Nov. 16, p. 703, 1872.—*Westrumb*, 'De Helm. Acanth.' (good figs.), 1821.

SECTION IV.—Part II.—Suctoria (Leeches)

As explained in the Introduction we must regard the Leeches and many allied forms of Suctorial Annelids as creatures possessed of semi-parasitic habits. They are, perhaps, something more than what Van Beneden styles "free parasites"—an expression which almost looks like a contradiction of terms. I cannot here, however, stop to discuss questions which lie, as it were, on the border-land of parasitology. Three species of leech are more or less commonly employed in medicine. These are the grey leech (*Sanguisuga medicinalis*, Savigny), the green-leech (*S. officinalis*,

Sav.), and the dragon-leech (*S. interrupta*, Moq.-Tandon). The two former abound in Central and Southern Europe, being also present in North Africa, the last named inhabiting Barbary and Algeria. So abundant are leeches in the country bordering the Mediterranean that during the invasion of Egypt by Napoleon the French soldiers suffered seriously from their attacks. When the men lay down to drink, the leeches (*Hæmopis sanguisorba*, Sav.) affixed themselves to their mouths and nostrils, producing serious distress. They also attacked horses, camels, and cattle. In like manner the Ceylon and Philippine Island leeches (*S. ceylonica*, Moq.-Tand., or *S. tagalla*, Meyen), of which there are several varieties, prove exceedingly troublesome to Europeans. These leeches, not being aquatic forms, occupy woods and damp places. Unless the limbs of travellers are well protected, the presence of the blood-suckers is soon discovered by the trickling of blood from the limbs and lower part of the body. The leeches even sometimes creep up to the neck and other adjacent parts. These "free parasites" also attack horses, causing much loss of blood. Terrestrial leeches abound more or less in all warm countries. Sir J. Hooker encountered them in the Himalayas, and they are common in China, Japan, Java (*S. Javonica*, Wahlberg), and other eastern parts. They likewise abound in Brazil and Chili. The American leeches for the most part belong to the genus Hæmenteria (*H. Mexicana*, *H. officinalis*, and *H. Ghiliani*, Filippi). The last named is common in Brazil, the other two being Mexican forms. Another species, which is blind, has been found in Brazil by F. Müller (*Cyclobdella lumbricoides*). Not only the above-named species, but also many other kinds of leeches are in the habit of attacking man and the domestic animals, but the subject is too extended and special to be fully dealt with in this work. Almost a legion of species are known as externally parasitic upon Fishes, Chelonian and Batrachian reptiles, Crustaceans, and Echinoderms.

Bibliography (No. 36).—*Blainville*, 'Dict. des Sci. Nat.,' tom. xlvii, p. 257.—*Brandt* (und *Ratzeburg*), 'Medicin. Zoologie,' Bd. ii.—*Brightwell*, 'Ann. and Mag. Nat. Hist.,' ix, 1842.—*Diesing*, 'Syst.,' vol. i, p. 465, and "Revis. der Myzelminth. (Abth. Bdellideen)," in 'Sitzungsb. der math.-nat. Cl. d. k. Akad. der Wissensch.,' Bd. xxxiii, s. 473.—*Ebrard*, 'Compt. Rend.,' 1856, p. 1012.—*Idem*, 'Monogr. des sangues Méd.,' 1857.—*Filippi, De*, 'Mem. Accad., &c., Torino,' and in 'S. und

K. Zeitsch.,' 1829.—*Idem*, "Nuovo genere," &c., in 'Gaz. Med. Lombard,' 1849.—*Grube*, 'Fam. d. Annelid.,' s. 109.—*Hofmeister*, in 'Burmeister's Zeitung für Zool.,' 1848.—*Johnson*, 'Treatise on the Medicinal Leech.'—*Leuckart*, l. c., Bd. ii, s. 634-739 (with many refs.)—*Leydig* ("Anat."), 'S. und K. Zeitsch.,' Bd. i.—*Moquin-Tandon*, 'Monogr. de la fam. des Hirudinées,' 1846.—*Idem*, in his 'Medical Zoology' (Hulme's edit.), 1861, p. 137.—*Müller, F.*, in 'Archiv f. Naturg.,' 1846. —*Pereira*, in his 'Materia Med.,' vol. ii, p. 2197, 1853.—*Savigny*, 'Descript. de l'Egypte,' 2nd edit.—*Idem*, 'Syst. des Annélides,' 1820.—*Schmarda*, 'Neue wirbell. Thiere,' Bd. i (quoted by Leuckart).—*Virey* (and *Serullas*), in 'Journ. Pharm.,' 1829, p. 614.—*Wagener*, in 'Troschel's Archiv,' 1858, Bd, i, s. 244 *et seq.*—*Wahlberg*, in 'Œfvers. Kongl. Vetensk. Akad. Forhand.,' Stockholm, 1855.

SECTION IV.—Part III.—Arachnida (Pentastomes, Mites, Ticks).

The Trachearian division of the Arachnida comprises a few internal parasites that attack man, and many ectozoa which are parasitic upon man and animals. The species can only be noticed very briefly.

Pentastoma tænioides, Rudolphi.—In the system of classification adopted by Diesing, this entozoon and its allies are placed in the division *Cephalocotyleen* and therefore, in association with the Cestodes, with which, however, it has no structural affinity. It was long ago pointed out by Van Beneden, T. D. Schubart, Leuckart, and others, that the pentastomes were Acarine and Lernæan Arthropods; the genus being osculant between the Acaridæ and Lernæadæ. The whole subject is discussed in Leuckart's profound memoir quoted below.

The adult *Pentastoma tænioides* is characterised by the possession of a vermiform, lancet-shaped body, flattened at the ventral surface, attenuated posteriorly, and marked transversely by about ninety rings (fig. 50, 1 and 2). The cephalo-thoracic segments are continuous with the body, each supporting a pair of strong retractile chitinous claws; four in all. The head is truncated, furnished with an oval mouth, armed with a horny lip. The integument of the body is perforated with numerous respiratory openings or stigmata. These are wanting in the

cephalic segment. In the larval state (= *Pent. denticulatum*) the body is armed with numerous rows of small, sharply pointed spines. The adult female measures from three to four inches in length, but the male is only about an inch long. The genital aperture of the female is situated at the extremity of the tail, that of the male being placed at the front part of the abdomen in the middle line. The mode of reproduction is oviparous, accompanied by a subsequent and complete metamorphosis.

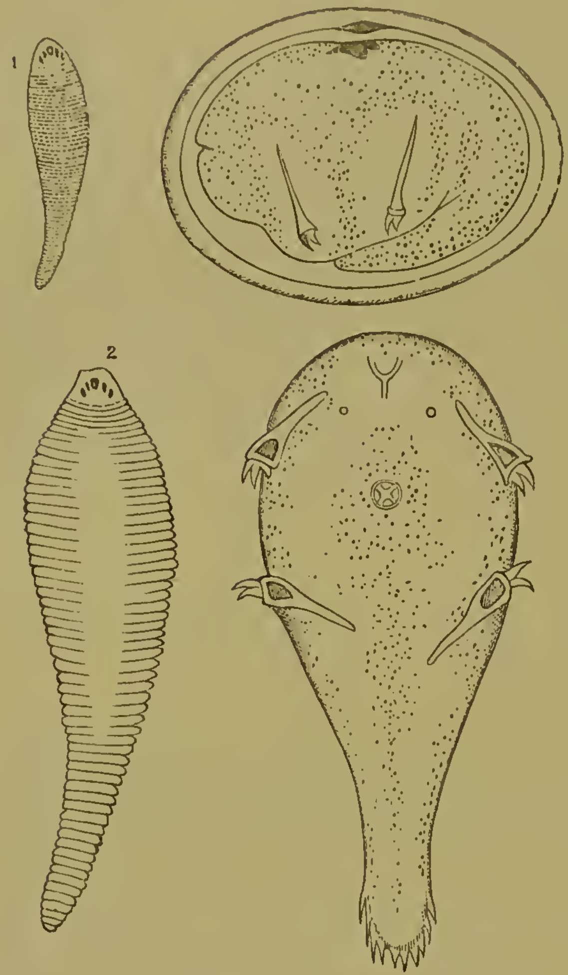

FIG. 50.—*Pentastoma tænioides.* (1) Male and (2) female, of the natural size. The egg and embryo highly magnified. After Leuckart.

In the mature condition this parasite infests the nostrils, and frontal sinuses of the dog and wolf, and also, though more rarely, the nasal cavities of the horse and sheep. In the pupal and larval states it sometimes occurs in the abdominal and thoracic cavities of the human body, but it is more frequently found in herbivorous mammals, such as the sheep, deer, antelope, peccary, porcupine, guinea-pig, hare, and rat. According to Creplin, it infests the domestic cat. In these animals and in man the young worms occupy little cysts within or upon the peripheral parts of the liver and lungs. I have occasionally found them free in the cavities of the abdomen and pleura.

In the course of the development of this entozoon, Leuckart recognises four well-marked stages. The *first* is that of the embryo with a boring apparatus. In the *second* stage, the embryo has become transformed into a motionless pupa. The *third* is the ordinary larval condition characterised by numerous rows of small spines in addition to two pairs of double claws.

The *fourth* is the sexually-developed stage, furnished with a simple hook-apparatus, and without integumentary denticles. "Our Pentastomes, therefore," says Leuckart, "exhibit two kinds of larval forms, an earlier and later one, such as takes place in other animals; this also occurs even in insects (*Strepsiptera* and *Meloidæ*), only that, in our case (*i. e.* in *Pentastoma*), both do not immediately follow one another, but are separated by a resting condition, which I have designated as the pupa stage. In choosing this name I do not mean to express a complete identity of this intermediate state with the pupal sleep of insects."

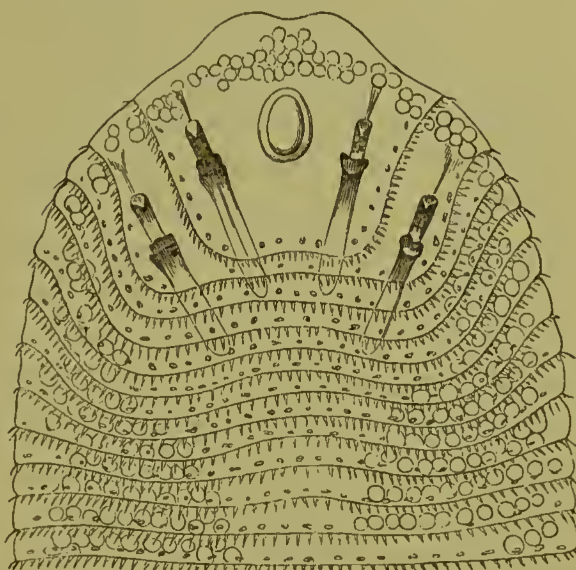

Fig. 51.—Upper third of the body of *Pentastoma denticulatum*. Original.

So far as my own observations extend, the pupa, in its later stages, closely resembles the free larva; but, as Leuckart points out, the earlier stages are very different. The embryo, after encystation, repeatedly casts its skin, and during the intervals of these several successive moultings, the young animal makes rapid growth, accompanied by a series of structural changes. Passing through these it at length acquires the perfected larval state (*P. denticulatum*).

As regards the occurrence of this entozoon in the human body, the best account is that given by Frerichs. As quoted in my previous work from Murchison's edition of Frerichs' well-known clinical treatise, the German *savant* remarks:—"The Pentastoma is a parasite which has only recently been discovered in the human subject, but it is, nevertheless, far more common in the human liver than the echinococcus. It is devoid of clinical importance, because it does not give rise to any functional derangements. Pruner ('Krankheit des Orients,' 1847, s. 245) was the first who pointed out the existence of the Pentastoma in the human liver. On two occasions he found an encysted parasite in the liver of negroes at Cairo, the nature of which, however, he did not accurately determine. Bilharz and Von Siebold ('Zeitschr. für Wissench. Zoologie,' Bd. iv, s. 63)

recognised in it a new variety of Pentastoma, to which he gave the name of *P. constrictum*. In Germany the Pentastoma was found in the human liver by Zenker ('Zeitschr. f. ration. Med.,' 1854, Bd. v, s. 224) ; it occurs, however, not only in this gland, but also in the kidneys, and in the submucous tissue of the small intestine (Wagner). The parasite is by no means rare with us. Zenker, at Dresden, succeeded in finding it nine times out of 168 autopsies ; Heschl, at Vienna, met with it five times out of twenty autopsies ; Wagner, at Leipsig, once in ten. According to Virchow, it is more common in Berlin than in Central Germany. During six months at Breslau I met with it in five out of forty-seven dead bodies. The Pentastoma-endemic in Germany is not identical with that which occurs in Egypt ; the former is the *P. denticulatum* of Rudolphi." This clear statement of Frerichs is valuable ; but, as Murchison has also pointed out, there is some discrepancy between Frerichs and Küchenmeister's record of Zenker's experience. According to Küchenmeister, Zenker met with the Pentastoma thirty times in 200 autopsies.

Although from a purely clinical point of view, and speaking generally, this worm, as Frerichs says, can claim little attention, yet, as we shall see (when treating of the parasites of the dog), it occasionally proves fatal to the canine bearer. Not only so, it may even occasion severe inconvenience to the human bearer. Quite recently a remarkable instance of this kind occurred in Germany, some notice of which appeared in the 'Medical Times and Gazette,' Jan. 4th, 1879, as follows :

" Dr Landon of Elbing ('Berl. Klin. Wochenschrift,' No. 49, 1878) relates the case of a workman, aged forty-two, who soon after the Franco-German campaign of 1870 was laid up with pain in the hepatic region, jaundice, and gastric disturbance, which symptoms persisted more or less until 1874, when he came under Dr Landon's care with an attack apparently of perihepatitis. It then appeared that since 1871 he had also suffered from severe attacks of epistaxis, which occurred often twice in the same day. The patient complained of a feeling of painful pressure in the left nasal cavity, but with the speculum nothing but a moderate degree of inflammatory swelling could be detected. Suddenly, at Easter, 1878, a parasite was disloged from the left side of the nose by a violent sneeze, and from that moment the epistaxis has not occurred. Its cause proved to be the *Pentastoma tænioides*."

As the full-grown parasite occupies the nasal chambers of the dog, it is clear that the act of sneezing will be liable to transport the eggs and their contained embryos to the face and other exposed parts of persons who fondle dogs. In this way the germs will readily gain access to the human mouth. Ordinarily, the germs are introduced into the human stomach with uncooked vegetable food and fruits, to which they adhere after expulsion from the animal's nostrils. The slimy nasal mucus secures this attachment, especially when it has become dry by exposure to the air. On reaching the stomach the embryos escape the egg-coverings and bore their way directly to the liver and other viscera, in which organs they becomes encysted and undergo the pupal transformation. Eventually they acquire a length of 2 to 2½ lines (*P. denticulatum*). After a while the capsules enclosing the larvæ undergo calcareous degeneration, the parasite perishing.

In the case of dogs it is easy to perceive that when the animals are engaged in devouring the flesh of herbivora, the liberated larvæ will often come in contact with their noses. In this way contraction of the body, aided by the integumentary denticles, will secure their entrance into the nasal cavities. For our own security, therefore, we should avoid contact with dogs which frequent butchers' shops and knackeries, and be sure that our market-garden fruits and vegetables are carefully washed before they are brought to table.

Pentastoma constrictum, Von Siebold.—This parasite is at present only known to us in the immature condition; unless, indeed, as is by no means improbable, the adult worm has been described under some other name. It was first discovered by Pruner on two occasions in negroes, and he also subsequently found two specimens of the worm preserved in the Pathological Museum at Bologna, which had been removed from the human liver. Pruner also found it in the giraffe. Bilharz afterwards frequently detected it in the livers of negroes at Cairo. It differs from the larval form of *P. tænioides* in not possessing integumentary spines; moreover, it is a much larger parasite. The cephalothorax is furnished with four foot-claws, and the elongated abdomen displays twenty-three rings placed at tolerably regular intervals. The anterior part of the animal is obtusely rounded off, the caudal end being conical. The worm usually attains a length of rather more than half an inch, whilst the breadth scarcely exceeds a line.

An extremely interesting account of this worm has been published by Prof. Aitken, accompanied with illustrations by Dr H. C. Gillespie, taken from specimens in the Pathological Museum at Netley. Two cases are recorded. In one of these the encysted worms were found in the liver and lungs, and in the other in the liver only. In Dr Crawford's account of the post mortem in the last-mentioned case, Prof. Aitken quotes him as saying: "These worms varied in length from an inch to an inch and a half, and were found coiled up like a watch-spring, in small sacs scattered throughout the whole organ." The patient was a private of the 1st West India Regiment, and died at Bathurst, Gambia, in 1854. In the other case, where the lungs and liver were infested, the patient was an African, about twenty-one years old, who had enlisted into the 5th West India Regiment at Up Park Camp, Jamaica. He had, a few months previously, come from the slave depôt at Rupert's Valley, St Helena. According to the post-mortem report, furnished by Mr Kearney (staff surgeon), the lower lobe of the right lung contained one or two yellow specks. "When cut into, worms were seen regularly encysted in its substance." The surface of the liver was dotted over "with about twenty or thirty yellow specks, similar to those seen in the lung." The longest of these specimens was a trifle less than three quarters of an inch.

FIG. 52.—*Pentastoma constrictum*. Magnified four diameters. After Bilharz.

Whether *Pent. denticulatum* be or be not devoid of clinical interest, it is quite clear from Aitken's account that *P. constrictum* is a formidable parasite and one that occasionally proves fatal to the bearer. As his remarks suggest, a parasite that can produce both pneumonia and peritonitis is not a creature that either the physician or the sanitarian can afford to ignore. Lastly, I must again express my belief that the so-called *Echinorhynchus*, described by Welch, if it be not the *Pentastoma denticulatum*, must either be referred to *P. constrictum* (in an early larval condition), or to some other hitherto undescribed pentastomatoid larva.

BIBLIOGRAPHY (No. 37).—*Aitken, W.*, "On the occurrence of *Pentastoma constrictum* in the Human Body as a cause of painful Disease and Death," repr. from the 'Science and Practice of Medicine,' 4th edit., 1865.—*Bellingham*, in 'Ann. Nat. Hist.,'

vol. xiv, p. 162.—*Blanchard,* in 'Ann. des Sci. Nat.,' ser. 3, t. viii, and in 'Règn. Anim.' (with figs.).—*Cobbold,* 'Entoz.,' p. 393 *et seq.*—*Idem,* in 'Quart. Journ. Med. Sci.,' 1859, p. 205. —*Idem* ("*P. cephalophi*"), in 'Linn. Trans.,' xxii, p. 357, and xxiii, p. 350.—*Idem,* in 'Zool. Soc. Proc.,' 1861, p. 124.—*Diesing,* 'Syst.,' i, p. 609.—*Idem,* 'Revis. der Cephalocot.,' s. 327.—*Frerichs* (l. c., in text), vol. ii, p. 276.—*Klob* (und *Schroff*), in 'Gesellsch. d. Aerzte,' Wien, 1860.—*Küchenmeister,* l. c., i, s. 370, Eng. edit., tab. viii.—*Idem* (with *Van Beneden*), in 'Bullet. Acad. Belg.,' xxii (with figs.), 1855.—*Landon* (quoted in text).—*Leuckart,* in 'Zeitsch. f. rat. Med.,' 1857; see also "Obs. on the development and early condition of the *Pent. tænioides,*" in 'Ann. Nat. Hist.,' vol. iii, 3rd series, 1859; also my translation of his "Further Observations on the development of *P. tænioides,*" from 'Henle and Pfeufer's Zeitsch.,' in the 'Quart. Journ. of Micr. Sci.' for 1859.—*Idem,* 'Bau und Entwicklungsgeschichte der Pentastomen, nach Untersuchungen besonders von *P. tænioides* und *P. denticulatum,*' Leipzig, 1860.—*Moquin-Tandon,* 'Med. Zool.' (Hulme's edit.), "The Linguatula," p. 329.—*Pruner* ("Nematoideum") in 'Krankh. d. Orient.,' 1847.—*Schubart,* 'S. und K. Zeitschr.,' Bd. iv.—*Welch,* see Bibl. No. 36.—*Zenker,* in 'H. und Pf. Zeitschr. f. rat. Med.,' 1854, s. 212 (with figs.).

The ectoparasitic arachnidans comprise a great variety of mites and ticks (*Acaridæ* and *Ixodidæ*) more or less proper to man, and also a number of creatures which, though hardly to be reckoned as human parasites, are apt to transfer themselves from animals to man. Little more than an enumeration of the forms is possible here. The Common Scab or Itch insect (*Sarcoptes scabiei*) forms the type of a great variety of arachnids, generally spoken of as different species according to the host they dwell upon. Mégnin, however, in his beautiful memoir, quoted below, regards most of the forms of this genus (found on the horse, hog, sheep, dog, wolf, and other animals) as mere varieties. In man the female Acarus burrows beneath the skin, forming galleries or curved channels, in which she deposits her eggs. The irritation produced is not alone due to these excavations, but to the presence also of a poison which the mite discharges when feeding. The *Sarcoptes crustosæ* of Fürstenberg, producing the Norway itch, is a variety, if, indeed, it can be called as much. Under the frightful name of *Dermatophagoides Schérémétewsky* two parasites found on an

herpetic patient have been described as new to science by M. Bogdanoff, but Mégnin points out that these Acari are only female and young male representatives of his *Chorioptes setiferus* (var. *bovis*) respectively. In Newfoundland, Dr Le Roy de Méricourt discovered a singular species upon an officer who had come from Havannah (*Tyroglyphus Méricourti*, Laboulbène). It possesses enormous palpi, as in the genus *Chyletus* to which Robin refers it. Another ectozoon, placed by Mégnin and others amongst the lowest types of Arachnida, is the well-known *Demodex folliculorum*. It is a gregarious species, a

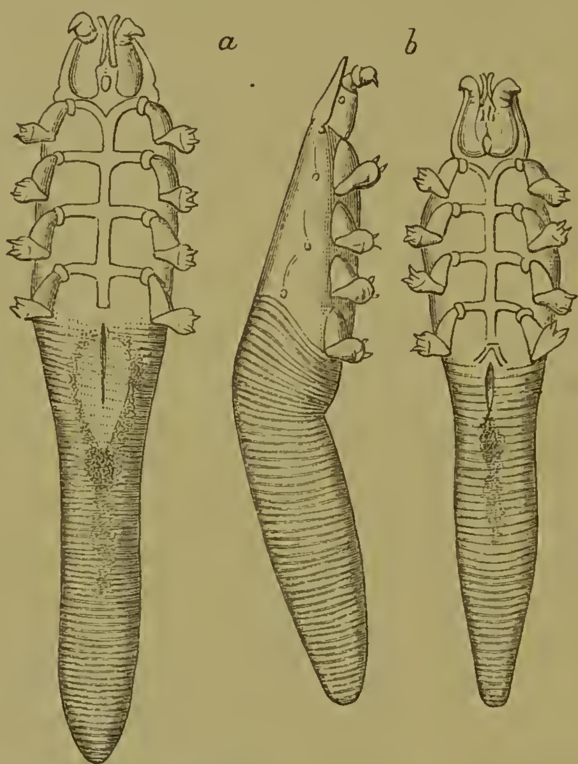

FIG. 53.—*Demodex folliculorum*, var. *caninus*. *a*, Female; *b* male. Viewed from below and in profile. Magnified 300 diameters. After Mégnin.

dozen or more examples often being present in a single dilated hair follicle. Though disfiguring to the human face it produces little harm. M. Gruby made it out to be a very common parasite, infesting forty out of sixty persons; but Mégnin, in his brochure (l. c. infra, p. 119), shows this statement to be an exaggeration. It infests on the average not more than one in ten persons. According to Gruby, moreover, a single follicle in the dog may contain 200 of these mites, another statement which Mégnin deems unreliable. The *Demodex* of the dog is only a variety (fig. 53). Many other human Arachnids have been found, some of which appear to be genuine species, whilst others are

accidental, so to speak. Of the former kind, perhaps we may reckon the two species discovered by Hessling (*Cœlognathus morsitans* and *Entarsus cancriformis*). Of the latter sort, those found by Busk, Simon, and Bory de St Vincent may be cited. The mite found in Simon's case was the *Dermanyssus avium*, which infests cage-birds. Probably it was the same species which Bory found on a lady; but in Busk's negro sailor the mite may have been *D. gallinæ* of the common fowl. Differing from the mites, proper, and also from the true ticks, are some bug-like forms called Argades. The two best known are the Miana bug of Persia (*Argas persicus*) and the Chinche of Columbia (*A. chinche*). Like their congener infesting pigeons (*A. reflexus*) these parasites are terrible blood-suckers. The bite of the Persian bug is so venomous as to have occasioned death. Various species of tick have been known to attack man, but the species have not been well determined. Although a human form has been described (*Ixodes hominis*, Koch), yet it is more probable that the species usually attacking man are the same as those known to infest the domesticated animals. In this list we may, therefore, reckon *Ixodes nigra*, *Ix. bovis*, *Ix. ricinus*, and *Ix. reduvius*. Cases in which one or other of these ticks occasioned much pain and distress are recorded by Hussem, Raspail, and Dr Cosson. Besides these there is a formidable tick well known at Angola (*Ix. monbata*). Its habits are like those of the common bed-bug. Severe pain comes on two hours after the person is bitten. It likewise attacks animals. The *Ix. carapato* is similarly troublesome in Brazil. Another very disgusting arachnid liable to attack man is the *Galeodes araneoides*. This large spider-like creature, two inches in length, commonly attacks camels and has an extremely venomous bite. One or more species of the dung-beetle mites (Gamasidæ) have also been known to fasten themselves on man. According to Latreille, they first get attached to the clothes of travellers, whence they pass to his body, and there shift about, producing great torment. Another disagreeable arachnid is the little harvest bug (*Leptus autumnalis*), which not only excites irritation during its crawling motion on the human skin, but even succeeds in burying itself near the hairs. The irritation thus produced is almost unbearable. This mite attacks various animals, especially dogs and cats. I myself once suffered severely from this species in consequence of fondling a young wild rabbit which, as I afterwards discovered, was

much infested. When the parasites had reached my left arm-pit they occasioned extreme torture. I have known these autumnal spiders to produce small suppurating boils on the abdomen. I may add that Dr Tilbury Fox has brought under my notice an instance where the hexapod larva of another species (probably *Trombidium cinereum*) was found to have occasioned severe irritation in a child.

Bibliography (No. 38).—*Alibert*, 'Maladies de la Peau,' Paris, 1833.—*Audouin, V.*, art. "Arachnida," in 'Todd's Cyclop.,' vol. i, 1836.—*Beneden, Van* (et *Gervais*), 'Zool. Med.,' 1859.—*Bourguignon* (et *Delafond*), in 'Rec. Vét.,' 1856.—*Idem*, in 'Mém. de l'Institut.,' 1862.—*Cobbold*, "Case of *Leptus* producing Boils," in 'Worms,' p. 140, London, 1872.—*Gamgee*, 'Our Domestic Animals in Health and Disease,' Edin., 1861.—*Gerlach*, 'Kraetze und Räude,' 1857.—*Hebra*, in 'Oester. Jahrb.,' 1864.—*Hering*, 'Die Kraetzmilben,' Stuttgard, 1845.—*Krabbe*, "Husdyrenes paras. Mider.," 'Tidssk. f. Vet.,' Rœk. 2, Bd. iii. —*Küchenmeister*, l. c., 1855, s. 412 (good figs.).—*Mégnin*, 'Monographie de la tribu des Sarcoptides psoriques.' (This work contains a full bibliography and numerous beautiful plates; see also Review in the 'Veterinarian,' Aug., 1877, p. 563).—*Idem*, "Mémoire sur un nouveau Symbiote (*Chorioptes*, Gerv.)," 'Journ. de l'Anat. et de la Physiol.,' 1872.—*Idem*, "Mém. sur un nouvel Acarien," *ibid.*, 1873.—*Idem*, "Mém. sur les Hypopes," *ibid.*, 1874.—*Idem*, "Mém. sur l'organisation et la distribution zoologique des Acariens de la famille des Gamasidés," *ibid.*, 1876.—*Idem*, "Mém. sur les métamorphoses des Acariens en général, et en particulier sur celles des Trombidions," 'Ann. des Sci. Nat.,' 1876.—*Idem*, "Des conditions de la contagion de la gale des animaux à l'homme," 'Arch. générales de Méd.,' 1876.—*Idem*, "Mém. sur le *Demodex folliculorum* (Owen)," 'Journ. de l'Anat. et de la Physiol.,' 1877.—*Moquin-Tandon*, 'Elém. de Zool. méd.' (Hulme's edit., p. 302–328), 1861.—*Williams*, in his 'Veterinary Surgery' (good figs., reproduced from Gamgee's translation of 'Gerlach,' &c.), 1872.

SECTION IV.—Part IV.—Crustacea (Gammaridæ).

Although multitudes of small Crustaceans are parasitic upon fishes, and some few of them adhere to oceanic mammals (Cetacea), I am sceptical as to the parasitism of Crustacea either

in or upon man. Many of the Amphipodous Gammari lead a sort of free parasitic existence, and they are themselves very liable to harbor larval parasites. As regards human parasitism from this source the only records known to me are those quoted below.

Bibliography (No. 39).—*Banon*, "Freshwater Shrimp, or *Gamarus pulex* (said to have been passed per anum)," 'Rep. of Path. Soc. of Dublin,' in 'Dub. Med. Press,' April 6, p. 351, 1864.—*Bartels*, "*Gamarus pulex* in the Human Subject, with a postscript by Troschel," trans. by Dr E. P. Wright, from 'Verhandl. des Naturhist. verein. der Preuss. Rheinl. und Westph.,' in 'Dubl. Med. Press,' 2nd ser., vol. ix, p. 407, 1864.—*Wright, E. P.*, 'Remarks on Dr Banon's Case' (see Bartels).

SECTION IV.—Part V.—Insecta (Coleoptera, Diptera, Hemiptera, Aphaniptera).

Whilst very many flies, bugs, lice, and fleas persecute animals, not a few of them also attack man. Several of the species are genuine parasites, others are semi-parasitic, and others, again, are altogether outside the border-land of parasitism in the ordinary sense of the term. In fact, it becomes difficult to say where the line of parasitism should be drawn. I cannot, however, ignore all notice of the insect tormentors, whether strictly parasitic or not.

At least fifty different species have been regarded as playing the rôle of parasitism in man. Amongst the Coleopterous parasites none is more authentic than *Blaps mortisaga*. At least half a dozen such cases have occurred. Mr Hope's catalogue of insects producing parasitism in man gives three examples of *scolechiasis* from this source. Sir J. R. Cormack published a fourth case, and I have recorded a fifth. In this instance I received the living larva from Dr Horne, of Barnsley, who procured it from an infant eleven weeks old. In my 'Introductory Treatise' I have alluded to the case of the girl Riordan, who not only passed per anum upwards of 1200 larvæ, but also several perfect insects. The case was first reported by Pickells, Thomson, and Bellingham. One of the other authentic cases, in which only a few larvæ were present, was recorded by Patterson, of Belfast, and the third case by Bateman. Mr Hope's

'Catalogue' originally appeared in the 'Transactions of the Entomological Society,' being afterwards published in the pages of the 'London Medical Gazette,' 1837. Patterson's case was also, I believe, first communicated to the Entomological Society.

As regards the mode in which the maggot gained access to the child in Horne's case, it was not easy to decide; but in the case of the girl Riordan the mode of ingress was sufficiently explained. The *Blapsidæ,* as a family, are closely allied to the meal-worms, and, like most of the *Tenebrionidæ,* are black and foul-smelling beetles, frequenting dark and damp situations, from which they escape only at night. The family comprises numerous species, of which probably not more than three are found in this country. They are abundant in Africa, especially in Egypt, where (according to Fabricius, as quoted by Westwood, Figuer, and others) the women eat *Blaps sulcata* cooked with butter in order to make themelves grow fat. The insects are also employed as specifics against ear-ache and the bite of the scorpion. The superstitious notion of a "charm" is generally at the bottom of these domestic remedies. In the girl Riordan's case, as Westwood observes (when epitomising Pickell's account), the parasites, as such, "probably originated in an absurd and superstitious practice, which she had for some time followed, of drinking daily for a certain time a quantity of water mixed with clay, taken from the graves of two Catholic priests, and eating large pieces of chalk. One of these beetles was immersed repeatedly in spirits of wine, but revived after remaining therein all night, and afterwards lived three years." The intolerance of light shown by the perfect insect seems to be equally shared by the larva. Of this fact I had repeated evidence by observing the behaviour of the living specimen sent to me by Dr Horne. Thus, when, on February 5th, 1877, I placed the maggot on the surface of some moist mould, scarcely half a minute elapsed before it commenced to bore its way downwards, and in less than a minute all but the tip of the tail had disappeared. In like manner, when, on the 7th, I raised the lid of the box, and found the maggot on the surface of the soil, it almost instantly proceeded to bury itself. Hope's list records no less than nine instances of parasitism in man from the larvæ of *Tenebrio molitor,* and he gives a score of other Coleopterous insects which he regarded as human "intestinal worms." Undoubtedly a large number of insect larvæ do get introduced into, and actually live within the human intestines.

Numerous cases of this sort have come under my observation, but it often requires a profound knowledge of entomology to determine the species. Several examples of œstridean larvæ occur amongst them. For one example of *Œstrus hominis* I am indebted to Mr Higginson, of Liverpool, who obligingly supplied me with notes of the case. Dr Kirk presented me with a small bot which he removed from Livingstone's leg. I afterwards deposited the African bot, in his name, in the Hunterian collection. Bates speaks of an Œstrus in Brazil producing boils in human flesh. Westwood quotes similar instances. Of these, one was extracted from the thigh by Dr Brick. Mr Doubleday, the entomologist, extracted one from his own leg, and M. Goudot, another entomologist, was also victimised in the same way. Both of these *savans* were travelling in America at the time. Two cases from South America were also recorded by Howship. In one the larva lodged in the back; in the other in the scrotum. Humboldt noticed that the Indians were much infested by Œstridæ. Three cases are severally recorded by Roulin, Guérin, and Audouin. Mr Stroop also mentions a case in which an Œstrus was removed from an ulcer on the shoulder of a boy in Texas. Another kind of bot known as the Macaco worm (*Cuterebra noxialis*) occasionally attacks man, but more frequently cattle and dogs. For one example, taken from the leg of a negro, at Belize, British Honduras, I am indebted to Dr Dobson (A. M. D., Netley). Hope's list records five cases of bots of *Œstrus hominus*, one of *Œ. Guildingii*, one of *Œ. bovis*, and thirteen others (belonging to the same genus) as having been noticed in man. Since his time many additional cases have been recorded by J. M. Duncan and others. In like manner a legion of cases in which the maggots of various Muscidæ have been noticed, either in, upon, or from the human body. At a meeting of the American Academy in April, 1859, Dr Leidy showed some larvæ of the bluebottle fly vomited by a child; five larvæ of the flower-fly (Anthomyia) from a physician's own person (which had produced choleraic symptoms); and nine examples of *Cuterebra noxialis*. I have myself encountered numerous insect larvæ in medical practice. Amongst others I have obtained the larvæ of *Anthomyia canicularis* in six or eight separate instances. One set of specimens, identified by Wunderlich, was sent to me by Dr Brandt, of Oporto. Drs Duffin, W. Fox, and Leared have supplied me with others. The larvæ described in Farre's case, not being setose, must be

referred to one or other of the Muscidæ proper. Mr Hope gave nearly forty cases of this kind, referable to eight different species of fly, and, as already implied, I have myself collected a great variety of the maggots of Muscidæ passed by the bowel, besides others obtained either from beneath the skin or from open ulcerations.

The flies hitherto noticed as supplying parasitic maggots in man are *Musca domestica, M. carnaria, M. larvarum, M. nigra,* and perhaps *M. Cibaria, M. stabulans,* and *M. Cæsar.* This last, a handsome fly, is the species which proves so troublesome to sheep. The habit which flies have of depositing their eggs in open wounds, when the victims are asleep, is a fertile source of this kind of parasitism. Some of the instances recorded by Kirby and Spence are revolting in the extreme. They quote the cases which came under Mr Sell's notice in Jamaica. In one instance the flies were hatched in a neglected blister on the chest; in another from the gums and inside of the cheek; and in a third, from the nostrils of a negro, from whom 235 larvæ were expelled. The case of the Lincolnshire pauper, Page, who was literally eaten up by maggots, is almost incredible. An equally horrible instance, however, is recorded by Cloquet. It is said that the Jamaica cases were all due to the larvæ of the bluebottle fly (*M. vomitoria*). An instance of the same kind has been recorded by Mr Knox (A. M. D.). Sufficiently revolting as these cases are, the horrors attending them are eclipsed by the habits of the larvæ of *Lucilia hominivora.* The best accounts of its habits are those by M. Coquerel, M. Saint-Pair, and M. Vercammer. The insects lay their eggs in the mouth and nostrils, and when the larvæ escape they devour the tissues surrounding the buccal cavity, the pharynx, glottis, frontal and nasal sinuses, even reaching the sockets of the eye. Several Cayenne convicts have perished from the maggots of this fly, which is also prevalent in Mexico. These are not, however, the only instances of maggots gaining access to the nasal chambers. In a case recorded by Dr Astros, of Aix, 113 were discharged from the nose of a woman; and M. Legrand du Saulle records an instance where a number of larvæ occupied the frontal sinuses of a girl, nine years of age. The larvæ produced persistent headache and convulsions. In the case recorded by Wohlfart, 18 larvæ were discharged from the nose of an old man, and in the example given by Latham several larvæ were obtained from the frontal sinuses of a woman. Bracey Clark also gives an instance in

which a bot was taken from a woman's jaw. Not improbably the well-known Indian disease, termed peenash, or worm in the nose, is due to the presence of Œstridean larvæ. Cases by Rustomjee and Lahory are quoted below. Possibly Stockett's is another of the same order. The case by Kilgour (Bibliog. No. 34) may be another. I may add that Moquin-Tandon gives an instance of the discharge of seventy-two bots, resembling those of the sheep, from a woman's nose ('Journ. de Vandermonde'). The rat-tail maggots or larvæ of *Helophilus* are parasitic. Two or three instances have been recorded from the horse. I possess one from the human intestine. Kirby also quotes an instance in which *Heloph. pendulus* was obtained from the stomach of a woman ('Philos. Mag.,' vol. ix, p. 366).

A vast number of non-parasitic insects are injurious to man and beast. Inasmuch as they subsist at the expense of their victims and also adhere to his person during their attacks for a shorter or longer time, they, like the leeches, may be spoken of as free parasites. The leg-sticker (*Stomoxys calcitrans*) penetrates through thick stockings, causing blood to flow freely. The clegg of the West Highlands (*Hæmatopota pluvialis*) also violently attacks man and beast, especially horses. The mosquito (*Culex anxifer*), the gnats (*C. pipiens, C. annulatus,* and *C. pulicaris*), and the midge (*Chironomus plumosus*) need only be mentioned. The creeping gnat (*Simulium reptans*) is also very annoying in Sweden. The rôle of the mosquito, as itself constituting a parasite-bearer, will be again referred to in the closing pages of this work (Book II, Section V). The bites of the tsetse (*Glossina morsitans*), though so destructive to the horse, ox, sheep, and dog, are not dangerous to man himself. According to Sir S. Baker, the seroot-fly, or zimb of Bruce, which is a species of *Pangonia,* is excessively annoying to travellers in Abyssinia. Amongst the hemipterous insects the common bug (*Acanthia lectularia*) is sufficiently blood-thirsty; but there is a far more sanguinary species of this kind in South America. This is the pampas benchucha (*Conorhinus nigrovarius*). Our distinguished countryman, Darwin, in his 'Voyage,' speaking of these wingless insects, says:—"Before sucking they are quite thin, but afterwards become round and bloated with blood. In less than ten minutes the insect is changed from being as flat as a wafer to a globular form." This insect somewhat resembles our water-scorpion (*Nepa cinerea*), a non-parasitic species whose bite causes severe pain,

as does also the wound inflicted by the water-boatman (*Notonecta glauca*). There are other species of bug, such as the *Acanthia rotundata* of Réunion Island and *A. ciliata* of Kasan, the bites of which are worse than that of the common species. The fly-bugs also, such as the *Reduvius personatus*, so common in France, and the *R. amœnus* of Borneo and Java, attack man, although their especial habit is to attack and destroy other insects, including bugs themselves. Other species or varieties of Reduvius (*R. cruentus*, and *R. serratus*) attack man. The last named is an Indian form, capable, it is said, of producing an electric shock.

Passing to the fleas, the most important and truly parasitic form is the chigoe or gigger (*Pulex penetrans*), This abounds in tropical America and the West Indies. The female insects only attack man, and this they do for the purpose of securing a lodgment for their offspring. They attack especially the soles of the feet, between the toes and near the nails. In bad cases the whole of the foot becomes affected. After the insect has penetrated the skin its body swells enormously and becomes a mere bag of eggs. This swelling causes active inflammation, which terminates in suppuration and the formation of open ulcers. The chigoe also attacks various animals. In addition to the common flea (*P. irritans*) other species infesting animals are said to attack man occasionally. As regards those degraded types of insects known as lice I can only afford space to remark that five species have been recognised as human. These are the head-louse (*Pediculus capitis*); the louse of the eyelids (*P. palpebrarum*); the clothes-louse (*P. vestimenti*); the distemper louse (*P. tabescentium*); and the pubic louse (*P. inguinalis*). The distress these creatures occasion is only fully known to physicians who deal with the obstinate cutaneous affections caused by their presence (*Phthiriasis*). Some of the lice found on negroes and Greenlanders are regarded as distinct varieties. Lice are abundant on animals, and some of the species are apt to transfer themselves from one host to another. Thus the *Ornithomyia avicularis* of cage birds has been found on man, whilst one or more of the numerous species infesting the common fowl are, by transfer, apt to produce a severe phthiriasis in the horse. The lice of the fowl belong to the genera *Leipurus*, *Liotheum*, *Menopon*, *Philopterus*, *Goniodes*, and *Goniocotes*. The unsuitableness of man's person as a habitation for bird-lice should, however, check the fear which many persons

have of handling fresh-killed poultry and game birds. Poultry lousiness in man is probably impossible from this source.

Bibliography (No. 40).—*Arture*, "Obs. sur le ver nommé Macaque," in 'Mém. Acad. des Sci.,' Paris, 1753.—*Bates*, "Œstrus in Man," 'The Naturalist on the Amazons.'—*Beneden, Van*, 'Animal Parasites and Messmates,' 1876.—*Idem* (with *Gervais*), 'Traité de Zool. Méd.'—*Blood, M.*, "Case of Larvæ (*Musca sarcophaga*) expelled alive in the Fæces," 'Beale's Arch. of Med.,' vol. iii, p. 134, 1862.—*Brinton* (similar case), 'Arch. of Med.,' vol. iii, p. 133, 1862.—*Bouyer* (quoted by Figuer), 'Tour du Monde,' p. 318, 1866.—*Clark, Bracey*, in 'Linn. Trans.,' vol. iii, 1797 (the jaw-case at p. 323), and vol. xv, 1827. —*Idem*, 'Essay on Bots,' 1815.—*Cloquet, J.*, "Case of Blindness from Worms (larvæ of Musca) in the Eyes," from 'Arch. Gén. de Méd.,' in 'Lancet,' 1828.—*Cobbold*, "On *Blaps mortisaga* as a Human Parasite," 'Brit. Med. Journ.,' 1877, p. 420. —*Idem*, "Entoz." ('Hope's List.'), p. 416.—*Idem*, in 'Worms' ("Leptus," &c.), p. 140, 1872.—*Coquerel* (quoted by Figuer). —*Cormack, J. R.*, "Exhibition of a Larva (*B. mortisaga*) passed by a Child," 'Month. Journ. Med. Sci.,' vol. i, 1841.—*Crumpe, S.*, "History of a Case in which Worms (larvæ of a beetle) were discharged from the Stomach," from 'Trans. of the Roy. Irish Acad.,' vol. vi, in 'Med. Facts and Observ.,' vol. viii, p. 229, 1800.—*Denny*, 'Monog. Anoplurorum Brittaniæ,' 1842. —*Duncan, J. M.*, "On the Occurrence of Bots in the Human Subject," 'Edin. Vet. Rev.,' vol. i, p. 275, 1858-59.—*Idem*, "The Larva of *Œstrus bovis* in the Human Subject," 'Rep. of Edin. Med.-Chir. Soc.,' in 'Month. Journ. of Med. Sci.,' July, 1854.—*Farre, A.*, "On the Larva of *Anthomyia canicularis*," 'Micr. Journ. and Struct. Rec.,' 1841, p. 129, and in 'Trans. of Micr. Soc. of Lond.,' orig. ser., p. 51, 1844.—*Figuer*, in 'The Insect World' (good figs.), Janson's edit., 1869.—*Furlonge*, "Anat. of Pulex," in the 'Journ. of the Queckett Club,' vol. iii.—*Geer, De*, 'Mémoires pour servir à l'Histoire des Insectes,' 1773.—*Gervais* (see Van Beneden).—*Hill*, "Account of the Larva of a supposed *Œstrus hominis*, or Gad-fly, which deposits its Eggs in the bodies of the human species, with particulars of a Case," 'Edin. New. Phil. Journ.,' vol. xxii, p. 284, 1830.—*Hilaire* (see St Hilaire).—*Hope*, "Tables of Cases of (spurious) Intestinal Worms," 'Lond. Med. Gaz.,' 1837-38.—*Hoppe*, "Case of Larvæ of Insects (*Musca stabulans*) passed by Stool," from 'Bibl. für Läger,' in 'Med.-Chir. Rev.,'

1842.—*Hopper, R. S.*, "Insects (Stratiomis) voided with Urine," edit. note in 'Micr. Journ. and Struct. Rev.,' p. 160, 1841.—*Joly*, 'Recherches sur les Œstrides en général,' &c., Lyons, 1846.—*Keferstein*, 'Sur l'Oistros,' Isis, 1827.—*Kirby* (and *Spence*), 'Introd. to Entomology,' 7th edit., 1856.—*Knox, M.*, "Maggots, the larvæ of the Bluebottle Fly, in Syphilitic Ulceration of the Throat," 'Lancet,' Oct. 6, 1877, p. 514.—*Lahory, B. T. C.*, "On *Peenash*, or Worms in the Nose," 'Ind. Ann. of Med. Sci.,' 1855, and 'Edin. Med. Journ.,' 1857.—*Leach*, "Œstridæ," in 'Wernerian Trans.,' 1817.—*Leidy*, in 'Proc. Phil. Acad. Nat. Sci.,' 1859, p. 7.—*Maclean*, "On the Oistros," 'Linn. Trans.,' vol. xiv, 1824, and in 'Zool. Journ.,' vol. i and iv.—*Metaxa*, "Vom Œstrus (u. s. w.)," in 'Neuen Nord. Beitr.,' Bd. i, and in 'Mém. de Zool. Med.,' Rome, 1835 (quoted by Westwood).—*Moquin-Tandon*, 'Med. Zool.' (l. c., Bibl. No. 38).—*Newport*, art. "Insecta," 'Todd's Cyclop.,' 1839.—*Rustomjee, B.*, "Case of Worms in the Nose, or 'Peenash,'" in 'App. to Bomb. Med. and Phys. Soc. Trans.,' No. vii, new ser., p. 21, 1861; see also Lahory, on 'Peenash.'—*Saint-Hilaire*, "Sur l'Œstre chez l'homme," in 'Ann. Soc. Ent. de France,' 1833.—*Say*, "Brick's Case," in 'Trans. Acad. Nat. Sci. Phil.,' vol. ii.—*Sells*, in 'Trans. Entom. Soc. Lond.;' see also Lemprière's 'Diseases of the Army in Jamaica,' vol. ii.—*Stockett, T. H.*, "An account of a Headache cured by the discharge of a Worm (?) from the Nose," 'Med. Com.,' vol. xix, p. 157, 1794, and in 'Trans. Coll. of Phys. Phil.,' vol. i, part i, p. 181, 1793.—*Stroop, St J.*, "Œstrus," in 'Amer. Naturalist,' vol. vii, p. 437.—*Tanner*, "On Lice," in his 'Pract. of Med.,' vol. ii, p. 429, 6th edit., 1869.—*Westwood*, in his 'Classification of Insects,' vol. ii, 1840.—*Wohlfart* (quoted by Moquin-Tandon).—*Yule*, "Case of Larvæ of Insects in the Human Stomach," 'Edin. Phil. Journ.,' and 'Lond. Med. Repos.,' 1825.

SECTION IV.—PART VI.—PROTOZOA (Psorospermiæ, Gregarinidæ, &c.).

The scope of this work does not demand that I should comprise within its limits any vegetable parasites; nevertheless, I must needs refer, however briefly, to certain confervoid and sarcodic organisms, which, for the most part, lie on the borderland of the animal and vegetable kingdoms. Professor Cohn

regards the bacteria as allied to the Oscillitoriaceæ He puts them in his order *Schizosporeæ.* It is of little moment, practically, where these protista forms are placed. Unquestionably many of them are parasitic, as they live in the tissues, fluids, and secretions of animal bodies, including man. Their presence in cattle is associated with an anthracoid disease (charbon), whilst in the human body they have been detected in connection with zymotic affections. They have been found by Cohn, Sanderson, Klebs, Chauveau, and others, either in the lymph of vaccine pustules, or in the miliary eruptions of typhus fever. Professor Beale, who was one of the first to observe these special organic particles in vaccine lymph, denies that they are true Bacteria; and, indeed, he warmly disputes the inferences that have generally been drawn from the fact of the presence of such particles in lymph, blood, and other nutrient fluids. The best known and defined forms are *Bacterium termo* and *Bact. lineola,* which are concerned in the production of putrefaction, *Bacillus anthracis,* found in the blood of animals suffering from carbuncular disease, *Micrococcus septicus,* found in typhus and pyæmia, *M. vaccinæ* of cow-pox lymph, and *M. diphthericus,* in diphtheria. As regards their prevalence in certain forms of relapsing fever, Sanderson states that Dr H. V. Carter, of Bombay, examined the blood of 250 fever patients and found *spirilla* in nearly every instance. From the independent observations of Pasteur, Sanderson, Lister, Tyndall, Bastian, Eberth, Roberts, Davaine, and many others, it seems clear that the Bacteria and their allies play an important part in association with certain morbid states. However, as regards the etiology of the maladies in which these organisms are found, it is perhaps too early to speak with absolute confidence. The subject cannot be dealt with here; moreover, it is outside the range of my personal investigations.

Passing to those protozoa which, although retaining some vegetable affinities, are more or less distinctively animal, I notice the obscure organisms termed psorosperms. In dealing with these I shall treat of the forms that infest both man and animals, confining my remarks to such as happen to have come under my own observation.

In the year 1865 the public were thoroughly roused to a sense of danger arising from the consumption of meat. The panic originated with the outbreaks of trichiniasis in Germany. During the excitement which subsequently prevailed at the time

of the rinderpest, all sorts of erroneous notions took possession of the popular mind, and the errors were stimulated by writers ignorant of helminthology. In January, 1866, I published a few observations, the purport of which was to show that certain microscopic organisms found in animals dying from cattle plague were harmless "parasitic Protozoa," possessing more or less striking vegetable affinities. About a week previously some interesting researches on these so-called cattle-plague bodies had been published by Dr Beale. Those who first saw these bodies thought they had stumbled upon organisms new to science. I showed that similar or analogous organisms were to be met with in a great variety of animals, and likewise in the human body. They had been called worm-nodules, worm-nests, egg-sacs, eggs of the common fluke, young "measles," corpuscles produced by muscular degeneration, psorospermiæ, stages of growth of gregarinæ, amœboid bodies, and so forth. In so far as the higher animals were concerned, Dujardin was the first to describe them. He found these organisms in a mole. This animal, however, having been fed upon earthworms known to harbour such parasites, there was no difficulty in accounting for the source of the psorosperms.

In 1853 Hessling discovered psorospermial sacs in the muscular substance of the heart, not only of the ox, but also of the sheep and roe. By him they were regarded as evidences of muscular degeneration. About ten years previously Miescher found similar bodies in the muscles of the mouse.

In 1857 Rainey described similar structures taken from the flesh of swine; and, in his memoir, he went so far as to maintain that these bodies were early stages of development of the common pork-measle. In the year 1858 Gubler wrote an important paper on this subject, in which he related a case where twenty cysts existed in the human liver. The cysts were of great size, mostly as large as a hen's egg, one of them being some six inches in diameter. Naturally, the largest had been diagnosed as an ordinary hydatid. However, on evacuating their contents (post mortem), they were found to harbor enormous quantities of minute corpuscles strictly analogous to those usually obtained from psorospermial sacs. Gubler believed he had stumbled upon masses of eggs of *Distoma hepaticum*, but in this he erred. Shortly after Gubler's discovery similar bodies from the human liver were described by Virchow; and in 1862, the subject was followed up by Dr Dressler, of Prague.

Dressler found in tho human liver a number of pea-shaped bodies, the milky contents (*breisubstanz*) of which displayed a multitude of the characteristic corpuscular elements referred to. These particles, already considered as equivalent to, if not identical with, the so-called pseudo-navicellæ of gregarinæ, were soon encountered by a variety of independent observers. Thus, Leuckart noticed these bodies in various animals; but with caution remarked:—"Concerning the nature of these formations I will not decide. To be candid, however, it appears to me to be in no way made out whether the psorospermiæ are to be considered as the result of a special animal development, whether they, like pseudo-navicellæ, are the nuclei of gregariniform productions, or whether they are the final products of pathological metamorphosis." Leuckart found these organisms in the intestines of a trichinised dog, also in a sheep and pig fed with Trichinæ. He also found them in the muscles of another pig fed with psorosperms, and likewise in the liver of various rabbits. He remarks that in swine these parasites are more abundant than measles. They were present in five of eighteen pigs, and also in two out of four sheep, whose flesh was especially examined. The observations of Lindemann at Nischney-Novgorod are particularly interesting. This medical officer discovered psorospermial sacs attached to the hair of a girl who was being treated in hospital for chlorosis. The sacs in question bore close resemblance to the bodies which we found in abundance in diseased and healthy cattle. It would further appear, from Lindemann's observations, that the affection is not very uncommon amongst the Russian peasants.

In connection with and attached to the same parasitically affected hairs Lindemann also noticed several movable gregarinæ; and partly from this circumstance he was led to believe in the existence of a genetic relation subsisting between the two kinds of bodies. He further expressed his conviction that the people contracted the disease by washing themselves with water in which gregarinæ abounded. Lindemann moreover refers to Lebert as having noticed similar parasites in a case of favus, and concludes that these organisms are of a vegetable nature. His opinion, though not shared by the majority of parasitologists, is nevertheless supported by the views of Robin, Leydig, and others. Of still higher interest are the observations of Lindemann respecting the occurrence of psorospermiæ in the capsule of the kidney of a hospital patient who died with Bright's

disease. The sacs in this case were remarkably small; nevertheless their corpuscular contents indicated their true nature. The pseudo-navicellæ measured only $\frac{1}{3000}''$ in diameter. Amongst other contributions of interest I may refer to those of Dufour, J. Müller, Creplin, Kölliker, Keferstein, Stein, Drummond, Lieberkühn, and E. Ray Lankester. I doubt if the vegetable organisms described by Prof. W. T. Gairdner can be referred to this group of parasites. At all events, by whatever name these spurious entozoa are called, they were first discovered by Dufour in insects, by Müller in fishes, by Miescher in the mouse, by Dujardin in the mole, by Hessling in the larger quadrupeds, and by Gubler in man. The results of my own examinations may be briefly re-stated. In the flesh of cattle I found psorospermial sacs varying from $\frac{1}{120}''$ to $\frac{1}{12}''$ in length, and in that of sheep from $\frac{1}{225}''$ to $\frac{1}{80}''$. The bodies were enclosed in well-defined transparent envelopes, and their contents exhibited indications of segmentation. In some specimens the segments displayed themselves as a complete cell-formation, the contents of each cell being uniformly granular. Under the $\frac{1}{4}''$ objective the contained granules were clearly visible, and on rupturing the sac their peculiar characters were at once manifest, each granule or corpuscle represented a pseudo-navicel, all displaying a tolerably uniform size, averaging $\frac{1}{2000}''$ in diameter. Some of the corpuscles were round, others oval, several bluntly pointed at one end, many curved and fusiform, not a few being almost reniform. Highly refracting points or nucleoli were visible in their anterior.

Turning to the practical aspect of the subject, I remarked that these bodies had nothing to do with the cattle plague. No one who carefully examined the flesh of animals that had died of rinderpest had failed to discover them; yet, in one or two instances they appear to have escaped notice. When it is considered how long it takes us to examine a few grains weight of muscle carefully, it is obvious that the body of a large beast might contain many hundreds of these organisms without our being able to detect their presence, except by a prolonged investigation. In the few rinderpest beasts, portions of whose flesh I submitted to the microscope, I should say there were not more than 100 of these bodies in one ounce of meat; but in the heart of a healthy sheep (which I afterwards ate) I calculated there were about 1000 parasites to the ounce, and in the heart of a healthy bullock (which likewise served me for a

meal) their numbers were rather in excess of those in the sheep. Altogether, at two meals, I could not have swallowed less than 18,000 of these psorosperms. Consumers of beef, mutton, and pork eat these bodies every day, but they take no harm because the parasites in question are not true helminths. Fine healthy beef has been returned to the butcher when it was as good as any other meat in the market. I have examined various kinds of meat, such as veal, pork, and mutton, but in none have I found so great an abundance of psorosperms as in beef, which was, notwithstanding, perfectly healthy and sound. I calculated that in one instance a single ounce of the flesh contained upwards of 2000 parasites. There is practically no limit to the extent of this kind of parasitism, and there is no organ of the body in which psorosperms may not be found. Moreover, the forms they display are exceedingly various. Psorosperms have been found by Siedamagrotzky in the muscles of the horse, and not very long ago, through the help of Professors Simonds and Axe, I had the opportunity to examine some peculiar worm-like structures which occupied the mitral valve of a horse. To the naked eye they looked like coiled nematodes, but I was soon convinced that they formed a peculiar type of psorosperm. A complete view of these bodies was a matter of great difficulty owing to the delicate nature of their limiting membrane and to the confusion of markings produced by the interlacing of the fibres of the chordæ tendinea. At length, by spreading a portion of the membrane of the valve over a large glass slide, and by allowing it to dry slowly, I found that the vermiform body presented neither beginning nor end. The appearances were curious and puzzling. The organism formed a flattened tube or sac, almost uniform in width and variously twisted upon itself. From the main tube there projected several hernia-like secondary loops or branches, most of them presenting less than half of the thickness of the former. These peculiarities, however, can hardly be understood without reference to the original illustrations. That these secondary coils were not of the nature of hernial protrusions was evident, not alone from the nature of their contents, but also from the fact that they showed distinct anastomoses. In fact, the parasite was a simple sac or bag with branches.

On puncturing the main tube with a fine needle a small quantity of tenacious creamy fluid made its escape. This, under Ross's $\frac{1}{4}$-inch lens, resolved itself into a few excessively

delicate sarcode globules surrounded by fine granules. The granular matter displayed a tendency to collect itself in the form of oval masses without showing any trace of a limiting border. One of these masses, measuring $\frac{1}{250}''$ in length, I examined under a Wasserlein-objective, when I further ascertained that the elementary particles or granules were uniformly oval in shape, rather highly refractive, their size scarcely exceeding $\frac{1}{8000}''$ in diameter. The sarcode corpuscles, on the other hand, were of different sizes, ranging between $\frac{1}{3000}''$ and $\frac{1}{1600}''$ in diameter.

From the facts thus elicited, negative as they were in respect of helminthic structure, I could see no escape from the conclusion that we had to deal with a new form of psorospermial bag, whose granular contents consisted of excessively minute pseudo-navicellæ. In the centre of the largest hernia-like loop there was a clear oval disk, which at first brought to my mind the nucleus of *Monocystis* infesting the earth-worm, but it was merely a vacuole.

The case recorded by Gubler reminds me of another remarkable instance of psorospermial cysts, in this case associated with true hydatids. In 1873 Dr Whittell sent me particulars of a case in which the contents of an hydatid of the liver (drawn off, during life) consisted of shreds of a true hydatid, a few echinococcus-hooklets, together with multitudes of spindle-shaped amœboid particles of excessive minuteness and delicacy. The bodies, floating in a transparent fluid, formed a thick milky or creamy fluid, resembling pus in appearance; but there was no trace of pyæmia. Judging from Dr Whittell's figures, he must also have found a solitary microscopic nematoid hæmatozoon, the nature of which was not clear to him. I believe it to have been a specimen of *Filaria sanguinis hominis*. Be that as it may, the case is altogether unique and deserves further elucidation.

As regards the higher forms of protozoa it must suffice to allude to the *Cercomonas hominis* of Davaine, found in the dejections of cholera patients, to the *Cerc. urinarius* of Hassal and *C. saltans* of Ehrenberg, to the *Trichomonas vaginalis* of Donné, detected in the vaginal mucus, and to the *Balantidium coli* of Claparède and Lachmann, originally found by Malmsten in the human colon. The *Balantidium*, or *Paramœcium coli*, has frequently been observed in the evacuations of fever patients, and it has also been found by Dr Treille in patients suffering

from the Cochin-China diarrhœa. Monads have also been found in the stomach and intestines of the hog and various other animals. Infusorial parasites are particularly abundant in batrachians, the *Bursariæ* of frogs and toads being familiar to every helminthologist.

BIBLIOGRAPHY (No. 41).—*Arloing* (and *Tripier*), in 'Gaz.-hebd.,' 1873, p. 574 (quoted by Davaine).—*Balbiani*, 'Compt. Rend. Soc. Biol.,' 1867, p. 103 (quoted by Davaine and Bastian). —*Bastian*, "On the Nature of the so-called *Sarcina ventriculi*," 'Brit. Med. Journ.,' Feb. 3, 1872.—*Idem*, "On Heterogenesis in its relation to certain Parasitic Diseases," 'Brit. Med. Journ.,' Feb. 24 and April 20, 1872 (see part iv, p. 417, with figs. from Balbiani).—*Beale, L.*, "Entozoon-like bodies in Muscles," in the 'Microscope in Medicine,' 4th edit., p. 485, 1878. — *Idem*, "Bacterium Hypothesis of Contagium," *ibid.*, pp. 313–321.—*Burnett, W. T.*, "On Psorospermia, Mermithes, &c.," in a paper entitled 'Reviews and Records in Anat. and Physiol.,' in 'Amer. Journ. of Sci. and Arts,' vol. xviii, 2nd ser., p. 104, 1854.—*Carter, H. V.*, "On Spirilla," quoted by Sanderson in 'Brit. Med. Journ.,' Nov. 17, 1877, p. 700.—*Cobbold*, "Remarks on Spurious Entozoa found in Diseased and Healthy Cattle," 'Path. Soc. Trans.,' vol. xvii, p. 452, 1866, and 'Lancet,' Jan. 27, 1866, p. 88 ; see also Prof. J. Gamgee's work on the 'Cattle Plague.' *Idem*, "On Worm-like Organisms in the Mitral Valve of a Horse," 'Veterinarian,' Sept., 1877.—*Idem*, "On Psorospermiæ in the Eye of the Cod (Morrhua)," 'Linnean Society's Proc.,' May, 1862, and in 'Intellectual Observer,' 1862, p. 199.—*Cohn*, 'Nova Acta,' xxiv, s. 103 (quoted by Leuckart), Bd. i, s. 139. —*Creplin*, 'Wiegmann's Archiv,' 1842, s. 61.—*Davaine*, l. c., 2nd edit., "Synops. xxi" (with bibliog. refs.), 1878. — *Donné*, 'Cours de Microscopie,' Paris, 1847, p. 157.—*Dressler*, quoted by Leuckart, Bd. i, s. 141.—*Drummond*, 'Edin. Phys. Rep., 1852,—*Dufour*, 'Ann. des Sci. Nat.,' 1837.—*Dujardin*, 'Traité' (l. c., see Bibl. No. 1).—*Eberth*, 'Zur Kentniss Bacteritischer Mykosen,' 1872.—*Eimer*, 'Ueber Psorospermien,' 1870.—*Gairdner*, 'Edin. Phys. Soc. Rep.,' 1853.—*Gluge*, "Cysts in Sticklebacks," 'Bullet. Acad. Roy. des Sci. de Bruxelles,' 1838.—*Gubler*, 'Mem. Soc. Biol.,' 1859, p. 657, and in 'Gaz. Méd.,' 1858, p. 61.—*Harz, C. O.*, "Eine neue Mikrococcusform im lebenden Thierkörper," 'Deutsche Zeitschrift für Thier-Medicin und vergleichende Pathologie,' f. Novemb., 1878.—*Hessling*, 'Sieb. u. Köll. Zeitsch.,' 1853, p. 196.—*Henle*, 'Müller's

Archiv,' 1845.—*Hollis, W. A.*, "What is a Bacterium?" repr. in the 'Veterinarian,' p. 205, 1875.—*Keferstein*, 'Götling. gelehrte Anzeigen,' 1862.—*Kloss*, 'Ueber Parasiten (u. s. w.)' (quoted by Davaine).—*Knoch*, 'Journ. de Russ. Kriegs. dep.,' Bd. xcv, 1866 (quoted by Leuckart and by Davaine).—*Kölliker*, in 'Zeitsch.' (by Sieb. and Köll.), 1848–49.—*Lambl*, 'Prager Vierteljahrschrift,' 1859.—*Lankester, E. R.*, "Recent Researches on Bacteria (with copious references)," 'Quart. Journ. Micr. Science,' Oct., 1878.—*Lebert*, 'Phys. Pathologique' (quoted by Leuckart).—*Leidy*, "Gregarina," 'Amer. Phil. Trans.,' 1851.—*Leisering*, "Bericht (u. s. w.)," in 'Sachsen,' 1865.—*Leuckart*, l. c., Bd. i, s. 135 and 740, and Bd. ii, s. 842 *et seq.*—*Leydig*, 'Müller's Archiv,' 1851, s. 221, in 'Micr. Journ.,' 1853, p. 206, and in 'Arch. f. Anat. und Phys.,' 1863, s. 191.—*Lieberkühn*, 'Müller's Arch.,' 1854.—*Lindemann*, 'Bullet. Soc. imp. des Naturalistes de Moscow,' 1863, and in 'Gaz. Méd. de Paris,' 1870, p. 86.—*Lister, J.*, "Natural History of Bacteria," 'Micr. Journ.,' Oct, 1873.—*Malmsten*, "*Paramæcium coli*" (quoted by Davaine, l. c., 2nd edit., p. 67).—*Miescher* (quoted by Leuckart and Siebold).—*Müller*, 'Archiv,' 1841, s. 477.—*Rainey*, 'Phil. Trans.,' 1857.—*Rayer*, "Singulière éruption sur un véron (Cyprinus)," 'Arch. de Méd. Comparée,' Paris, 1842 (quoted by Davaine).—*Rivolta*, "Psorospermi, &c.," trans. in 'Journ. des Vét. du Midi,' 1869, pp. 445 and 521.—*Robin*, 'Les Végét. Paras.,' 2nd edit., p. 291.—*Sanderson*, in 'Privy Council Reports,' 1874.—*Siedamagrotzky*, in 'Recueil de Méd. Vét.,' 1872, p. 460.—*Stein*, in 'Müller's Arch.,' 1848, and 'Ann. Nat. Hist.,' 1850.—*Idem*, "Abhandl. d. k. Böhmischen Gesellsch.," x, s. 69, oder Lotos, 1859, s. 57 (quoted by Leuckart, Bd. i, s. 151).—*Steinberg*, 'Walter's Zeitschr. f. die moderne Medicin,' 1862, and in Leuckart, Bd. ii, s. 844.—*Stieda*, 'Arch. f. pathol. anat.,' Bd. xxxv, and in Leuckart, Bd. ii, s. 846.—*Suriray*, "Sur quelques parasites du lombric," 'Ann. des Sci. Nat.,' 1836.—*Virchow*, "Zur Kentniss der Wurmknoten," 'Arch. f. Anat. u. Phys.,' xviii, s. 523.—*Vogel*, 'Path. Anat.,' i, s. 404.—*Waldenburg*, "Psorospermien," in 'Arch. f. Path. Anat.,' s. 435, 1867.—*Windbladh*, also *Wising*, 'On *Balantidium coli*' (quoted by Leuckart, Bd. ii, s. 846-847).—*Winkler* (see *Leisering*).

Appendix.—On various occasions I have dwelt upon the necessity of acquiring accurate information respecting the degree of mortality due to parasites, and in the present volume (p. 124)

I have referred to the defective evidences supplied by the returns of the Registrar-General in respect of the echinococcus disease. My object is not to cast blame upon those whose duty it is to publish the returns, but rather to call attention to the advantages that would follow if the Registrar-General were supplied with full and accurate information on this head.

Through the courtesy of Mr Noel A. Humphreys I have been furnished with the following official statement of the number of *Deaths from Worms* in England and Wales, as recorded in the Annual Reports of the Registrar-General throughout a decade of years :

	1868	1869	1870	1871	1872	1873	1874	1875	1876	1877
Total	172	148	151	160	154	183	188	227	204	225
Including—										
Porrigo . . .	15	13	9	9	9	14	5	16	7	13
Scabies	6	2	7	1	4	2	—	5	2	3
Tapeworm . . .	8	3	6	3	5	3	5	5	2	6
Hydatids . . .	20	20	33	37	41	34	29	43	31	51

Considering the prodigious advances in helminthology during the last half century, it is certainly remarkable that under the category of "worms," as a cause of death, only two kinds of true helminths should be mentioned in the Registrar's record. It will also strike the experienced hospital and dispensary physician as somewhat remarkable that of the two death-producing parasites above named one of them should be the "tapeworm." Now death from *Tænia* is certainly a very rare occurrence, although grave nervous symptoms are not unfrequently due to its presence in man. Thus, I am inclined to regard the 46 reported instances of death from this cause as a redundant estimate. On the other hand, I am surprised to see no specified instances of death from lumbricoid Ascarides, from Oxyurides, or even from Cysticerci, which now and then take up their residence in the human brain.

As regards hydatids I believe the returns to be excessively deficient. In place of an average of 34 deaths annually from this cause in the United Kingdom I am of opinion that at least 400 deaths are due to hydatids. This opinion and the data on which it was founded were communicated by me twelve years ago to the Linnean Society, and I have since become acquainted with facts which lead me to conclude that my original estimate was very much below the mark. The post-mortem registrar

of one of our large hospitals has told me that of late years as many as *ten* deaths might be reckoned as annually due to hydatids in their institution alone. At a smaller hospital I ascertained that the average was about *four*. Obviously, if these estimates are correct, the Registrar-General's returns for the United Kingdom do not record a tithe of the annual mortality due to hydatids. Perhaps another half century will elapse before the truth of my deductions be confirmed by the *official* returns. For me, it must suffice to have pointed to the desirability of securing more accurate records.

By a curious coincidence I had only just sent to press the sheet of this work recording the statistics of hydatid disease in Australia (p. 123), when a paper dealing with the same subject appeared in the 'Lancet.' I refer to the brief memoir of Dr David Thomas, of Adelaide, South Australia, which was published on the 1st of March, 1879. Dr Thomas writes as follows:

"It is well known that Australia presents an extraordinary prevalence of hydatid disease, but, as far as I know, no definite statistics have been published to illustrate the fact. Consequently, some months ago, with the kind assistance of the Hon. W. Morgan, the present Chief Secretary of South Australia, I endeavoured to procure reports from the Governments of Victoria, New South Wales, Queensland, New Zealand, Tasmania, and Western Australia, upon this question. Unfortunately, the mode of registration of the causes of death in most of these colonies was such as prevented the necessary replies being supplied. However, it appears that in Tasmania no deaths were returned from this disease in the ten years 1867-77. During the greater part of the same period no separate classification of hydatid disease had been adopted in New South Wales; but in 1875 four deaths were attributed to hydatids; in 1876, eleven were so returned. In Victoria, however, the record of deaths from this cause is far more complete, and I append a table based upon the returns from that colony.

"One case, in which hydatid of the kidney was present, accompanied by malignant disease of bladder, with stricture, was not returned as a case of hydatid causing death.

"During the decade 1867-77, 2·5 per 1000 deaths were due to hydatid disease. In 183 out of the 307 cases the liver was either solely or conjointly with other organs the seat of disease. Holding the second place in frequency come the lungs in 71 cases, *i.e.* 53 simple and 18 complicated."

Table of Deaths returned as being due to Hydatid Disease in the Province of Victoria during the ten years 1867–77.

Year.	Liver.	Lungs and pleura.	Brain and spinal cord.	Heart and Pericardium.	Kidney.	Spleen.	Pancreas.	Omentum.	Ovary.	Womb (?)	Abdominal cavity.	Situation not recorded.	More than one organ invaded.	Total annual deaths.
1868	17	5	...	1	...	...	...	...	...	...	2	7	1 (*a*)	33
1869	6	8	1	...	...	...	1	...	...	...	2	1	3 (*b*)	22
1870	10	2	1	...	...	...	...	...	...	...	...	4	...	17
1871	4	6	1	...	...	1	...	...	...	1	...	1	1 (*c*)	15
1872	19	3	1	1	...	...	...	...	...	...	2	2	1 (*d*)	29
1873	17	3	2	...	...	...	...	...	...	...	...	2	5 (*e*)	29
1874	21	10	1	...	...	...	1	...	...	...	...	6	2 (*f*)	41
1875	29	7	...	2	...	1	...	...	1	...	3	2	2 (*g*)	47
1876	23	1	...	...	2	...	...	...	...	...	1	4	5 (*h*)	36
1877	20	8	...	1	...	1	...	1	...	...	3	2	2 (*i*)	38
Totals	166	53	7	5	2	3	2	1	1	1?	13	31	22	307 in 10 yrs.

(*a*) Lungs and kidneys.
(*b*) In two instances liver and lungs; in the third case liver and brain.
(*c*) Lungs and liver. (*d*) Lungs and abdominal cavity.
(*e*) In three cases liver and lungs; in one kidney and abdomen; in another liver, lungs, omentum.
(*f*) Liver and lungs.
(*g*) One liver and lungs; the second case lungs and heart.
(*h*) Three cases liver and lungs; one liver and kidney. (*i*) Liver and lungs.

Such are the returns as recorded by Dr Thomas. If a comparison be instituted between the data supplied by his decade-report and those supplied by the decade-report which I have previously adduced (p. 123), it will be seen that as regards the returns for the years 1868-72, inclusive, both reports are in perfect agreement. Of still more interest also is the circumstance that whilst, on the one hand, out of the total of 307 deaths given in Dr Thomas's table, 116 occurred during the first semi-decade (*i.e.* from 1868 to 1872, inclusive), on the other hand, no less than 181 deaths occurred during the second semi-decade (*i.e.* from 1873 to 1877, inclusive). This increase of 45 deaths during the later semi-decade is very significant. It points either to the fact of more careful returns having been made, or to an actual increase in the fatality of the disorder. Possibly both the causes alluded to operated to affect the returns. Be that as it may, Dr Thomas's record is highly instructive, and should stimulate the profession in England to supply our Registrar-General with more precise data wherewith to construct his annual reports.

BOOK II.

PARASITES OF ANIMALS.

In dealing with this division of the subject it will be impossible to give more than the faintest outline. Let it be borne in mind that quite as much information might be offered by me respecting the parasitism of each of the commoner domestic animals as has been already advanced in regard to the helminthism of man. That would by no means exhaust the subject. Thus treated, a score of volumes, each equal in size to this, would barely suffice to cover the whole ground of Parasitology; and yet there are not wanting intelligent persons who regard Helminthology as unworthy of their attention. These persons form a far too prevalent type of educated ignorance, and unfortunately, it is just this class of people who enjoy the prerogative of educational responsibility. Even our metropolitan scientific institutions, expressly raised for the purpose of diffusing useful knowledge, shrink from the revelations of parasitism. Dominated by the miserable conception which judges that the life-history of a worm cannot prove either interesting or instructive to their audiences, they let slip the acquisition of scientific data, a knowledge of which might enable them to combat successfully some of the most terrible evils to which human flesh, in common with that of animals, is heir.

In the following few pages many new points of departure for fresh scientific work will inevitably be suggested; and if I only succeed in conveying to the working student an adequate grasp of the whole subject, especially in its bearings on the welfare of the higher domesticated animals and man, I shall have accomplished all that I can reasonably hope to do within the restricted limits of space at my command.

SECTION I (Mammalia).

In dealing with this class of hosts, exclusive of man, I shall notice the entozoa of the various orders successively, taking the arrangement which I employed many years since when writing the Mammalian Division of a popular treatise called the 'Museum of Natural History.' The internal parasites of those orders which happen to embrace important domesticated animals will necessarily receive more attention than the others; some notice of the ectozoa being likewise added.

Part I.—Quadrumana (Monkeys).

Monkeys are less afflicted with flukes than most animals. The species known to me are *Distoma laciniatum*, found by Brongniart in the pancreas of *Simia maimon; D. orbiculare* and *Amphistoma emarginatum*, from the intestines of *Cebus trivirgatus;* and *Bilharzia hæmatobia*, a single specimen of which I obtained from *Cercopithecus fuliginosus*. The monkeys of the Old World rarely harbor full-grown tapeworms, but Cysticerci are abundant (*Cyst. tenuicollis, C. cellulosa, C. pileatus, C. crispus*). The common hydatid (*Echinococcus polymorphus*) has been found in many of the Simiæ, and by myself in a Madagascar lemur (*L. macaco*). Dr Leidy also obtained three hydatid cysts from a large monkey. On the last day of the year 1857 I obtained some polycephalous hydatids (*Cœnurus lemuris*) from a ring-tailed lemur. They infested the liver, being more abundant in the lungs. They occupied both sides of the chest. Loose and detached specimens also existed in the cavity of the right pleura. Most of those occupying the chest were connected to the pleura, forming vesicular, semi-transparent masses, varying in size from a filbert to a large walnut, many being united in bundles of much larger size. One of these masses is here drawn (1, fig. 54). It consists of four large Cœnuri, their combined pedicles forming a single stalk. A fifth hour-glass-shaped rudimentary Cœnurus is also visible. Every Cœnurus supports a variable number of lobules, each lobe supporting one or more papillæ. Here and there the papillæ resemble chains of beads. No trace of tapeworm heads could be seen, but under a half-inch objective glass, I found some flat papillæ presenting oval depressions at the surface (2, fig. 54).

On examining some of the larger papillæ they were found to consist of membranous layers folded one within the other. These were carefully dissected and examined with the aid of needles, when each one showed in the centre a well-formed

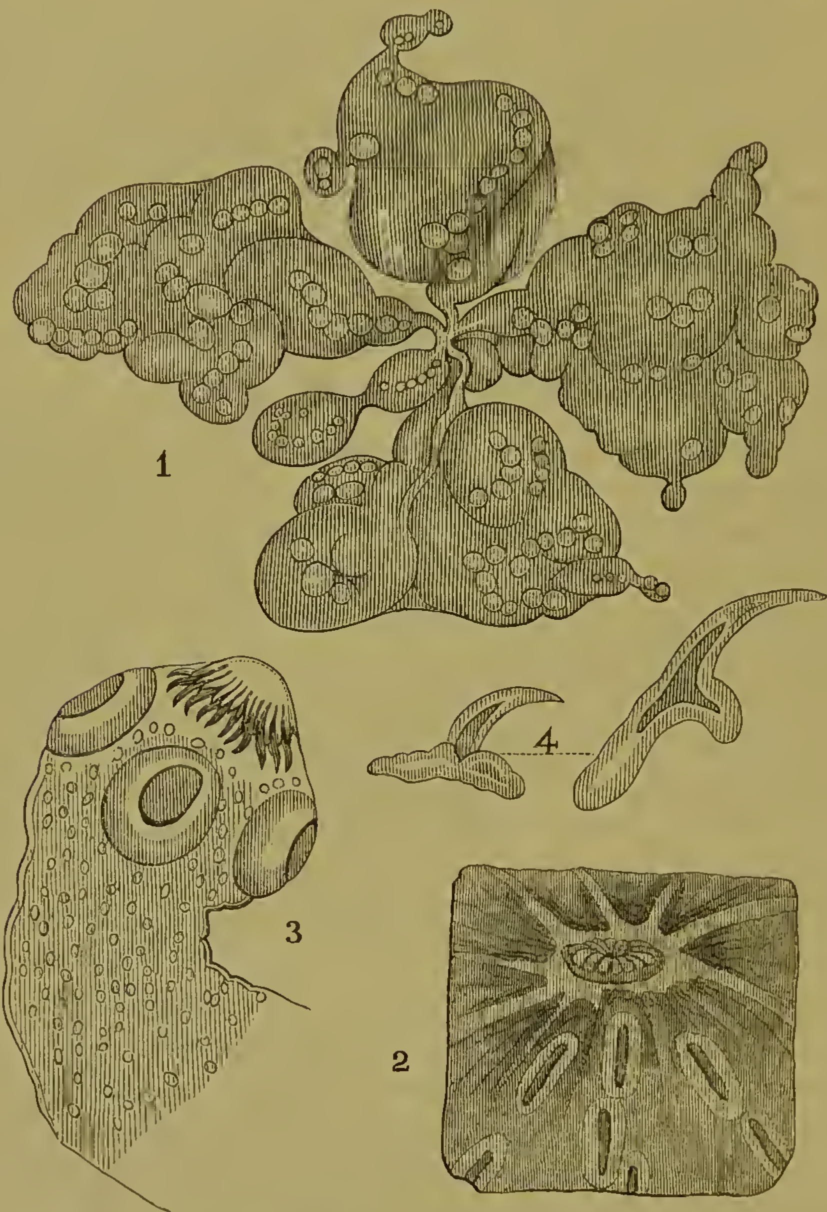

FIG. 54.—*Cœnurus lemuris.* 1, Colony; 2, portion of the ectocyst (enlarged); 3, scolex-head (magnified 40 diameters); 4, hooks (magnified 260 diameters). Original.

tapeworm head with four characteristic suckers, and a prominent rostellum supporting a double coronet of hooks, thirty-two of the latter in all (3, fig. 54). The hooks displayed a marked disparity of size and form. Each hook showed conspicuous anterior and posterior root-processes, the larger set of hooks individually measuring about $\frac{1}{225}''$ and the smaller $\frac{1}{330}''$ in length

(4, fig. 54). There were numerous calcareous corpuscles. The interior of each vesicle was filled with a fluid, in which there were no free scolices. On referring to my notes I find that the lemur had arrived in England about four months previously.

Larval cestodes do not appear to be common in the monkeys of the New World (Cebidæ), nevertheless I found several Cysticerci in the liver of *Macacus radiatus* (Feb. 19th 1857), and a single specimen in the sooty monkey (Dec. 4th 1857). They were wrongly described by me as Cercariæ. The Cebidæ are largely infested with tapeworms (*Tænia megastoma* and *T. rugosa*). A species of Ligula (*L. reptans*) has likewise been found beneath the skin of *Callithrix sciureus* and in one of the marmosets (*Hapale melanurus*). Perhaps the most common helminth infesting monkeys is the nematode called *Filaria gracilis.* I have examined specimens from the orang, the capuchin, and the spider monkey. This parasite commonly occupies the abdomen, coiled beneath the peritoneum, or within folds of the mesentery. It sometimes occurs beneath the skin, or within the connective tissue of superficial muscles. The female worm has been known to reach a length of five feet. In 1873 Mr Samuel Smith, of Clifton, sent me five specimens of this worm. From one of the males, which measured twenty inches in length, I procured some spermatozoa, and found their long diameter to average $\frac{1}{1400}''$. These corpuscles and other structures, as well as the worm itself, are figured in my 'Notes on Entozoa' quoted below. Next in frequency, perhaps, is the whipworm (*Tricocephalus dispar*), which monkeys of all kinds harbor in common with man. Besides these nematodes, *Physaloptera dilatata* is found in the stomach of American monkeys, and *Ascaris distans* also (in the large intestine of marmosets more particularly). This Ascaris has also been found in *Cercopithecus fuliginosus* and in *Simia sabæa.* A small spiroptera is said to infest the walls of the stomach of *Simia maimon.* To Dr Murie I am indebted for a large roundworm (*Ascaris lumbricoides*) taken from the intestine of a chimpanzee (*Troglodytes niger*), and also for a smaller nematode taken from a green mona-monkey (*Cercopithecus*). This I have described and named *Ascaris cuspidata.* From the intestines of a chacma (*Cynocephalus porcarius*) M. Schafhert procured sixteen examples of a small strongyle (*Str. attenuatus*, Leidy).

The singular monkey known as *Tarsius spectrum* is liable

to be attacked by a filaria (*F. lævis*), which is found beneath the skin. At least two species of Echinorhynchus (*E. spirula* and *E. elegans*) are known to infest monkeys. I have carefully examined and figured *E. elegans* in the 'Zoological Society's Proceedings,' from specimens supplied to me by Dr Murie. They had been obtained from a pinche-monkey (*Hapale œdipus*) from New Granada. I am under the impression that Diesing's original description of this parasite is the only one that exists. I have gone over his numerous memoirs contributed to the Vienna Academy, but can find nothing beyond the specific characters given in his 'Systema.' All the specimens in the Vienna Museum, whence his description is taken, were collected by Natterer. They were procured from the marakina (*Midas rosalia*), from two other true marmosets (*Hapale ursula* and *H. chrysoleuca*), and from a squirrel monkey or tee-tee (*Callithrix sciureus*). In the monkey which died at the Zoological Society's Gardens the cause of death was not clearly due to the parasites; nevertheless, the mucous layer of the intestine, to which the entozoa were attached, showed deep conical pits or depressions at the spots where the worms had anchored themselves. During the perfect retraction of the proboscis of this Echinorhynchus the centre is represented by a wide opening which communicates with a cavity beneath. The end of the neck thus forms a sort of collar, or rosette, made up of rays arranged like the spokes of a wheel. When the proboscis is exserted this collar is more or less convex, but it becomes slightly concave when the proboscis is retracted. Diesing recognised twenty-four rays; they probably vary from that number up to twenty-eight, at least I counted twenty-seven in my specimens. During exsertion the proboscis forms a nipple-like projection. According to Diesing it supports three rows of hooks, but I certainly saw four rows. When separately magnified these hooks present very different appearances as to size and contour. These variations I believe to be due to growth. The largest hooks measured about $\frac{1}{200}''$ in length.

As regards insect parasites, it is well known that monkeys are largely infested by fleas, but the species have not been much studied. The same may be said of their mites (*Acaridæ*). A species of Pentastoma (*P. tornatum*, Creplin) has been found occupying little cysts of the peritoneum and omentum in *Simia maimon* and *S. cynomulgus*. Under a synonym (*Linguatula Diesingii*) it has been very fully described by Van Beneden.

Another species (*P. subcylindricum*) has been found attached to the lungs and liver of a marmoset (*Hapale chrysopygus*). Dr Leidy found five specimens of *P. euryzonum* in cysts on the subperitoneal surface of the liver of *Cynocephalus porcarius*. Leuckart believes that Dr George Harley's *P. polyzonum* is the adult state of *P. euryzonum*, and that *P. subcylindricum* is the larva of *P. proboscideum*, found in *Boa constrictor* and other serpents.

Bibliography (No. 42).—*Beneden* (see Van Beneden).—*Cobbold*, "On *Filaria gracilis* and *Ascaris cuspidata*," in 'Zool. Soc. Proc.,' Feb. 3, 1874, p. 124.—*Idem*, "List of Entozoa, including Pentastomes, obtained from Animals dying at the Menagerie in 1857-60 inclusive," 'Proc. Zool. Soc.,' 1861. —*Idem*, 'Entozoa,' p. 119.—*Idem*, "On Parasite-Larvæ (Cœnurus and Echinococcus of the Lemur)," 'Intell. Observer,' vol. iii, pp. 86–96.—*Idem*, "Bilharzia from Cercopithecus," in 'Synops. of Distomidæ,' 'Proc. Linn. Soc.,' 1860, Zool. Div., pt. v, p. 31, and in "Parasites from Zool. Gardens.," in 'Intell. Obs.,' June, 1862, p. 352.—*Idem*, "On *Echinorh. elegans*," 'Proc. Zool. Soc.,' 1876, in 'Notes on Entozoa,' pt. iii, plate xvi, p. 202.—*Creplin*, "On *P. tornatum*," 'Troschel's Arch.,' 1849, s. 54.—*Idem*, "*F. gracilis*," in 'Wiegm. Arch.,' 1851, s. 270.—*Diesing*, 'Syst.,' l. c., s. 611, and in 'Sitzb. d. k. Akad.,' 1854, s. 598, —*Harley, G.*, in 'Proc. Zool. Soc.,' 1857, p. 12.—*Leidy, J.*, "On Pentastoma," 'Proc. Phil. Acad. Nat. Sci.,' 1850, p. 97.—*Idem*, 'Hydatids,' l. c., 1856, p. 46.—*Idem*, '*Strong. atten.*,' l. c., p. 54.—*Leuckart*, 'Bau und Entwicklungsgeschichte der Pentastomen,' 1860, "*P. polyzonum*," 'Synops.,' s. 153.—*Molin*, "On *F. gracilis*," in 'Sitzungsb. d. k. Akad. d. Wissensch.,' 1858, Bd. xxviii, s. 376.—*Schneider*, 'Monag. der Nem.,' 1866, "*F. gracilis*," s. 87.—*Smith, S.*, "On *F. gracilis* found in connection with the Great Omentum of a Spider-monkey," 'Proc. of Bristol Naturalists' Soc.,' vol. i, 1873.—*Van Beneden*, "*Ling. Diesingii*," in 'Mém. Acad. Belgique,' vol. xxiii, 'Recherches sur l'organisation et le dévélopment des Linguatules, suivies de la description d'une espèce nouvelle provenant d'un Mandrill,' 1849.

Part II (Cheiroptera).

Until lately not very much attention had been paid to the parasites of bats, probably on account of the insignificance of

the hosts. However, whilst Dr Dobson has recently been extending the subject of Cheiropterology, Prof. van Beneden has added largely to our knowledge of the parasites of bats. In his beautiful memoir, the Belgian helminthologist asks whether the parasites quit their hosts during the period of hybernation, and then proceeds to answer that question in the negative. Should the bats die, the parasites of necessity share the same fate. It would appear, however, that the spermatozoa of the worms are capable of surviving their parents for a fortnight or even longer. Flukes abound; the most common species (*Distoma lima*) infesting the pipistrelle, noctule, mouse-colored bat, Natterer's bat, parti-colored bat, Daubenton's bat, whiskered bat, and the greater and lesser horseshoe bats. Almost as abundant is the *Distoma chilostomum* found in most of these bats, and also in Leisler's or the hairy-armed bat. Dujardin's *D. heteroporum* is a synonym of the species. Schreber's *Monostomum* is probably identical with Van Beneden's *Distoma ascidia*. This fluke he found in *Vespertilio marinus*, *V. dasycnemus*, *V. Daubentonii*, *V. emarginatus*, *V. serotinus*, *V. mystacinus*, *V. pipistrellus*, *V. auritus*, and in *Rhinolophus hippocrepis*. Another species, distinguished from *D. ascidia* by its large ventral sucker, has been found in great numbers in the noctule (*D. ascidioïdes*, Van Beneden). The cestodes of bats are not numerous. The best known species (*Tænia obtusata*) has been found in the serotine, in the mouse-colored bat, and in *Vespertilio lasiurus*. Another species (*T. decipiens*) occurs in *Molossus perotis*, and *Chylonycteris rubiginosus*, and a scolex, forming the type of a new genus and species (*Milina grisea*, Van Ben.) has been obtained by hundreds in the intestines of *Vesp. murinus* and *V. serotinus*. Of nematodes we have *Ophiostomum mucronatum*, Rud., and *Oph. spinosum*, W.-Suhm (from *Vespertilio mystacinus*), *Trichosomum speciosum*, Van Ben., *Strongylus tipula*, Van Ben., *Strongylacantha glycyrrhiza*, Van Ben., *Litosoma filaria*, Van Ben., *Ascarops minuta*, Van Ben., and one or two sexually-immature forms, either found loose in the tissues or occupying cysts. The Acanthocephala are not known to infest bats. Respecting insects, one family (Nycteribiidæ) is exclusively parasitic upon bats. They resemble the forest-flies in their habits. The best known species is *Nycteribia Latreillei*, but several others (*N. biarticulata* and *N. Sykesii*, Westw.) have been described. One or more of the Brazilian bats are infested by *Lipoptena phyllostomatis*, Nitsch, and

Westwood has obtained several allied forms of *Hipposcidæ* (of the genus *Strebla*), also from bats. As regards the true Arachnidans (mites and ticks), Van Beneden enumerates *Ixodes lividus*, Van Ben., *Pteroptus vespertilionis* and *P. arcuatus*, Koch, *Otonissus aurantiacus* and *Cerathophyllus octactenus*, both of Kolenati, and *Caris elliptica*.

Bibliography (No. 43).—*Audouin*, 'Ann. des Sci. Nat.,' xxv. —*Beneden, P. J. van*, "Les Parasites des Chauves-souris de Belgique," fr. vol. xl of the 'Mém. de l'Acad.,' 1873.—*Diesing*, 'Syst. Helm.,' ii, p. 530.—*Dufour*, 'Ann. des Sci. Nat.,' 1831. —*Dujardin*, l. c., p. 437.—*Kolenati*, 'Die Parasiten der Chiropteren,' 1857.—*Latreille*, art. "Nycteribie," in 'Nouv. Dict. d'Inst. nat.'—*Müller*, 'Zool. Danica,' ii, p. 43, "*Fasciola vesp.* (syn. *Dist. lima*)."—*Perty*, "Lipoptena," 'Del. an. art. Brasil' (quoted by Westwood).—*Rudolphi*, 'Synops.,' p. 117.—*Westwood*, "Mém.," in 'Zool. Soc. Trans.,' 1835.—*Idem*, 'Modern Classif. of Insects,' vol. ii, p. 585, 1840.—*Willemoes-Suhm, R. V.*, "Helminthologische Notizen," iii, 'Zeitsch. f. wiss. Zool.,' 1873.

Part III (Insectivora).

The entozoa of insectivorous mammals, though sufficiently numerous, are not important practically. The common hedgehog (*Erinaceus europæus*) is infested by four flukes (*Distoma pusillum*, *D. trigonocephalum*, *D. caudatum*, *D. linguæforme*), and also by three thorn-headed worms (*Echinorhynchus napæformis*, *E. amphipachus*, and *E. major*). Two tapeworms are also known (*Tænia compacta* and *T. tripunctata*). More attention has been paid to the round worms. A species of strongyle (*S. striatus*) infests the lungs, the male being readily distinguished by its nearly round hood. A second species of strongyle has been mentioned by Diesing, but it is more than doubtful. The lungs are also infested by a small trichosome (*Eucoleus tenuis* of Dujardin); another species of the genus (*Trich. exiguum*) infesting the stomach and small intestine. As the *Trichina spiralis* has been repeatedly reared by myself and others in the hedgehog, the little flesh-worm must also be noticed in this place. *Physaloptera clausa* occupies the stomach, and a minute Ascaris (*A. pusilla*) is found in cysts of the peritoneum. According to Wedl, the intestine of the Egyptian hedgehog (*Erinaceus auritus*) is infested by another

worm, which he calls *Pterygodermatitis plagiostoma.* This is allied to Froelich's genus *Rictularia.* As regards the mole (*Talpa europæa*), two flukes have been described (*Distomum flexuosum* and *Monostomum ocreatum*), also two round worms, namely, *Ascaris incisa,* occupying the peritoneum, and *Spiroptera strumosa* in the cavity of the stomach. Dr Schneider places the latter with the Filariæ. A little tapeworm (*Tænia bacillaris*) infests the small intestines, and a larval cestode occupies the liver and subcutaneous connective tissues. This is the well-known *Cysticercus talpæ,* which Leuckart and others have referred to as being the scolex or juvenile state of *Tænia tenuicollis* infesting weasles (*Mustelidæ*). The Cysticercus is also found in *Arvicola arvalis.* In regard to the shrews, many species of fluke have been described as occupying the intestines. In *Sorex araneus* and *S. leucodon,* the *Distoma migrans;* in *S. constrictus,* the *D. exasperatum ;* in *S. tetragonurus,* the *D. corrugatum* and *D. rubens;* the last-named fluke, with two others (*D. instabile* and *D. truncatum*), being also found in Daubenton's shrew. The tapeworms are numerous—*Tænia neglecta, T. furcata, T. uncinata, T. pistillum, T. tiara, T. scalaris, T. scutigera.* With the exception of the last named, all these forms occur in the common shrew. According to the investigations of M. Villot the cysticercal stage of *T. pistillum* is to be found in the glow-worm (*Glomeris*). This scolex (*Staphylocystis micracanthus,* Villot) multiplies by proliferation, and in this way the swallowing of a single intermediate host may result in the formation of a hundred or more tapeworms. Another species of Staphylocystis (*S. biliarius*) is considered by Villot to be the larval source of *T. scutigera* and *T. scalaris,* which are perhaps identical species. A small Echinorhynchus (*E. appendiculatus*), found in the intestines and also encysted in the mesentery of the shrew, in like manner becomes transferred to the stomach of the fox. The nematodes of shrews possess little interest. In the common shrew the only species known are *Trichosoma splenaceum* and an immature worm, whilst in *Sorex tetragonurus* we have *T. incrassatum,* occupying the tunica vaginalis of the testis, and *Strongylus depressus* in the intestines. Not many other insectivora appear to have been studied in relation to their internal parasites. A larval cestode has been noticed in the Russian musk rat (*Mygale*), and also a tapeworm (*Tænia sphærocephala*) in the golden mole (*Chrysochloris*). Several flukes and a tapeworm have been found in

the water-shrews (*Sorex fodiens*), but, so far as I am aware, nothing has been done in connection with the parasites of the *Macroscelidinæ*, of the Banxrangs (*Tupainæ*), or of the Tanecs (*Centites*) and their allies. The entozoa of the star-nosed and shrew moles of North America (*Condylura* and *Scalops*) also deserve attention. From the last-named genus (*S. canadensis*) Prof. Leidy obtained a single male spiroptera. It occupied the stomach and was only half an inch in length.

Bibliography (No. 44).—*Leidy*, "*S. scalopsis canadensis*," 'Proc. Phil. Acad.,' 1851, p. 156.—*Linstow*, "*D. cordatum*, Einige neue Distomen (u. s. w.)," 'Arch. für Anat.,' 1873, s. 95. —*Molin*, 'Una Monografia del genere Physaloptera,' Wien, 1860 (p. 7, "*P. clausa*," and p. 31, "*P. limbata*").—*Idem*, 'Nuovi myzelmintha,' Wien, 1859, p. 10, Spec. No. 8.—*Idem*, 'Una Monogr. del genere Spiroptera,' Wien, 1860, p. 25, Spec. No. 22.—*Schneider*, 'Monogr. der Nematoden,' Berlin, 1866, s. 103, Spec. No. 39.—*Stieda*, in 'Troschel's Archiv,' 1862, "Description and figs. of *Tænia uncinata* and *T. furcata* of the Shrew."—*Thomson*, art. "Ovum," in 'Todd's Cyclop. of Anat. and Phys.,' contains figs. and description of *T. pistillum* (from Dujardin), vol. v, p. 28.—*Villot, A.*, "On the Migrations and Metamorphoses of the Tapeworms of the Shrews," in 'Ann. of Nat. Hist.,' March, 1878, from 'Comptes Rendus,' Nov. 19, 1877, p. 971.—*Wedl, K.*, "Zur Helminthenfauna Ægyptens," 'Sitzungsb. d. math.-naturw. Classe' (u. s. w.), Bd. xliv, Abth. i, s. 464.

Part IV (Carnivora).

Notwithstanding the importance of the entozoa of this large section of mammals, I must deal with them very summarily, emphasising my remarks on the parasites of the dog and cat. Only a few of the ectozoa can be noticed.

The bears are much infested by nematodes, the species being *Ascaris transfuga* and *Spiroptera* (*Gongylonema*) *contorta* of Molin. The latter is found in the œsophagus. Immature round worms have also been found in cysts. These were erroneously described as cestodes by Zeder and Gmelin. The bear, however, is very liable to be infested by genuine Cysticerci. Retzius found them in the muscles, and they are described as examples of the ordinary hog-measle. The museum attached

to Guy's Hospital contains the heart of a bear which is largely infested by Cysticerci. A species of tapeworm has been found in the polar bear. The coati (*Nasua narica*) is infested by *Ascaris brachyoptera* in the intestine, by Molin's *Physaloptera semilanceolata* from the stomach, by *Echinorhynchus spirula*, *Tænia crassipora*, and *Ligula reptans*, the latter occupying the muscles. A second species of Ascaris (*A. alienata*) is described from *Nasua rufa*.

The racoons (*Procyon*) are infested by a species of pentastome (*P. subcylindricum*), and Prof. Leidy has described a threadworm (*Filaria insignis*) obtained from a cyst in the foot. The gluttons (*Gulo*) are liable to be infested by an Ascaris, a Ligula, and by *Eustrongylus gigas*. The giant strongyle also infests the coati (*Nasua*). The skunk harbors *Tænia crassipora*. The Hunterian Museum contains four specimens of *Strongylus cruciformis* taken from a badger (*Meles*). The otters are largely infested by flukes; *Distoma trigonocephalum*, *D. incrassatum*, and *D. rude* being found in *Lutra vulgaris*, *L. solitaria*, and *L. braziliensis*, respectively, the latter also harboring *Hemistoma clathratum*. Otters are likewise infested by *Ligulæ* and *Eustrongyli*. The weasels (*Mustelidæ*) are attacked by a legion of entozoa, comprising flukes, tapeworms, round worms, and thorn-headed worms; they are also liable to harbor many ectozoa, a large tick (*Ixodes*) being especially troublesome.

FIG. 55.—*Strongylus gigas*, coiled within the kidney of a coati. After Leuckart.

Amongst the nematodes is Van Beneden's *Filaroides mustelarum*, for specimens of which I am indebted to Mr Wright Wilson. This is found in the lungs, trachea, and in the frontal and nasal sinuses of the common marten (*Mustela foina*), in which situations it causes absorption of the cranial bones. This worm occurs also in the polecat (*M. putorius*), in the common weasel (*M. vulgaris*), and in the pine-marten (*M. martes*). The larvæ reside in frogs. Weasels are also very liable to have their kidneys invaded by *Eustrongylus gigas*. A

species of Ascaris and a Trichosoma (*T. entomelas*) are not uncommon in the intestines. In regard to the tapeworms, *Tænia tenuicollis* infests the polecat and the common weasel, and *T. intermedia* the pine-marten. The most common fluke of the weasel is *Distoma trigonocephalum.* This infests the intestine, while *D. megostomum* is found in the stomach. The stoat or ermine (*M. erminea*) harbors *Strongylus patens* and *Tænia brevicollis.*

The parasites of the civets, ichneumons and their allies, (*Viverridæ*) are of little importance. Many years ago I described a small fluke (*Distoma compactum*) obtained from the lungs of the common Indian ichneumon (*Viverra mungos*). It is figured in my 'Entozoa,' (p. 16). Two species of tapeworm (*Tænia platydera* and *T. genettæ*) have been found in the common genet (*V. genettæ*), and also a round worm (*Ascaris brachyoptera*). From another viverra (*V. senegalensis*) Dujardin obtained a strongyloid worm (*Dochmius crassus*). A species of mongoos (*Herpestes leucurus*) is likewise infested by tapeworms (*Bothriocephalus folium*).

Comparatively speaking, very few entozoa infest the hyænas. In this family I include the earth-wolf (*Proteles lalandi*). Some years back Prof. Flower sent me a large number of delicate nematodes found loose in the peritoneal cavity of this singular South African carnivore. The worms themselves were so peculiar that I was compelled to form a new genus for their reception (*Acanthocheilonema dracunculoides*). From the intestines of the common *Hyæna striata* Dr Lautner obtained *Echinorhynchus gigas.*

The parasites of the wolf, jackal, and fox family (*Canidæ*) have especial interest, as including those of the dog. I can, however, do little more than mention the names of the various helminths of the dog, and the sources whence they come. At the same time, I shall incidentally refer to the wild canine animals that happen to harbor the same parasites.

The flukes of the dog are few in number. Perhaps the most important is *Distoma conjunctum,* originally discovered by myself in an American fox (*Canis fulvus*) that died at the Zoological Gardens. Lewis, eleven years afterwards, found it in the pariah dogs of India, where it is of frequent occurrence. It infests the bile ducts. As already stated, Prof. McConnell

FIG. 56.—*Distoma conjunctum.* Eight parasites of the natural size. Original.

subsequently found this entozoon in man (1875), a second instance being recorded later on (1878). Another species of canine liver fluke has been described by Prof. Ercolani (*D. campanulatum*), besides which there is the winged species occupying the small intestines (*Holostoma alatum*). This latter is also found in *Canis azaræ*.

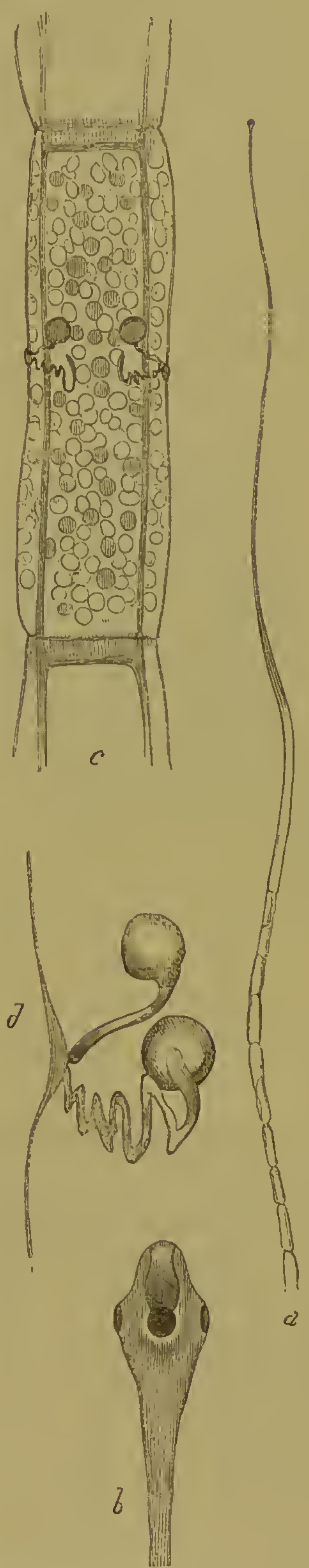

FIG. 57.—*Tænia cucumerina*. *a*, Strobile; *b*, head (enlarged); *c*, proglottoid, showing the sexual orifices; *d*, termination of the reproductive organs on one side. Magnified 60 diameters. Original.

The tapeworms of the dog are not only numerous, but also particularly injurious, alike to their bearers and to mankind. By experimental research we have ascertained the sources of most of the *Tæniæ*. The serrated species (*T. serrata*) is derived from *Cysticercus pisiformis* infesting hares and rabbits. This is common in sporting animals, owing to the careless practice of allowing gamekeepers and kennel masters to throw the fresh viscera of the intermediate hosts to the dogs. I have witnessed this stupid habit in the field. The cucumerine tapeworm (*T. cucumerina*) is, by most observers, considered to be identical with the *T. elliptica* of the cat. I regard it as a variety. This delicate species is excessively common and is now, through Melnikow's discovery, known to be derived from the louse of the dog (*Trichodectes latus*). This circumstance affords a curious illustration of the fact that an ultimate host may carry the intermediate host upon its back.

As regards the relative prevalence of these tapeworms in England, it may be said that whilst *T. serrata* occurs almost entirely in our harriers, greyhounds, sheep-dogs, and lurchers (taught to "pick up" hares), the *T. cucumerina* is liable to infest any variety of dog, and probably infests nearly 70

per cent. According to Krabbe the prevalence of the last-named species is 57 per cent. in Iceland and 48 per cent. in Copenhagen, whereas the *T. serrata* is almost absent from those countries. The gid tapeworm (*T. cœnurus*) is derived from the ordinary gid hydatid infesting the brains of sheep and lambs. The polycephalous bladder-worm (*Cœnurus cerebralis*), so familiar to agriculturists and veterinarians, is often confounded with the ordinary hydatid infesting ruminants. Cœnuri infest the soft parts of rabbits, but it remains to be shown whether they are the same species. Possibly the *Cœnurus cuniculi* is merely a variety. The gid tapeworm is not very abundant in England. In Denmark it appears to be rare, occurring in 1 per cent. only; but in Iceland Krabbe found it in 18 per cent. In common with other helminthologists, I have frequently reared this and the serrated species by worm feedings administered to dogs. The lettered tapeworm (*T. litterata*) is very commonly spoken of as the *Tænia canis lagopodis.* It was so named by Viborg, but I prefer the more distinctive nomenclature of Batsch. We know nothing, for certain, respecting the source of this entozoon. It is rare if not altogether wanting in Denmark, but abundant in Iceland (21 per cent.). I have obtained specimens from a cheetah (*Canis jubatus*) which died at the Zoological Gardens, and Mr W. H. Jackson, of Oxford, found it in a cat. The worm is certainly not confined to the Arctic fox (*C. lagopus.*).

A well-known tapeworm infests the fox which has not yet been noticed in the dog. This is the *Tænia crassiceps,* whose scolices (*Cysticercus longicollis*) reside in the viscera and soft parts of field mice and voles (*Arvicola arvalis, A. terrestris, A. amphibius*). This relationship was pointed out by Leuckart. Another tapeworm (*T. opuntioides*) mentioned by Rudolphi as occurring in the wolf, seems to be of doubtful authenticity. A formidable and not uncommon tapeworm is *Tænia marginata.* This large species occurs in at least 25 per cent. of English dogs, whilst in Iceland its prevalence reaches 75 per cent. In Denmark about 14 per cent. only.

It is well known that the larval or scolex stage (*Cysticercus tenuicollis*) of the margined tapeworm resides in the sheep and dog. In a feeding experiment with five examples of this bladder worm I reared five strobiles of ten days' growth. These immature tapeworms were each one inch long. By far the most important tapeworm of the dog, however, is the hydatid-forming species (*T. echinococcus*). This remarkable entozoon is the sole

cause of the terrible echinococcus disease, so prevalent in Iceland and elsewhere. Experimental research, initiated by von Siebold, has explained its origin; Van Beneden, Zenker, and others have also experimented successfully. Rarely attaining a length of $\frac{1}{3}''$, the perfect strobile is made up of only three proglottides in addition to the head, the lowermost segment being sexually mature. As hydatids (*Echinococcus veterinorum* or *E. hominis*) are found in a great variety of animals as well as in man, and as these bearers form so many kinds of intermediate hosts, it is easy to understand how readily dogs and wolves may acquire the sexually-mature tapeworm. I am in possession of hydatids from the liver of a clouded tiger (*Felis macroscelis*). In England the *Tænia echinococcus* is excessively rare, and has not been seen in any dog which had not previously been subjected to a feeding experiment. Mr Nettleship succeeded in rearing large numbers. In Iceland, Krabbe found dogs to be infested to the extent of 28 per cent., a proportion fully explaining the prevalence of hydatid disease in that country. The remaining tapeworms of the dog belong to the genus *Bothriocephalus*; of these, the broad tapeworm (*B. latus*) is best known, because it infests man. Diesing has described a variety found in the Pomeranian dog as a separate species (*Dibothrium serratum*). The museum of the Royal Veterinary College contains a very perfect specimen of *B. latus* from an English dog, but the parasite is of rare occurrence in this country. It is generally supposed that this tapeworm is derived from the consumption of fish belonging to the salmon and trout family, but Dr Fock, of Utrecht, thinks that the bleak (*Leuciscus alburnus*) is the usual intermediate host. I have already discussed this question at some length. Experimental proof is still wanting. In addition to *B. latus* the dog is liable to harbor *B. cordatus*, *B. fuscus*, and also two varieties of the last-named species (*B. dubius* and *B. reticulatus*, Krabbe). Taking the pit-headed tapeworms as a whole, their prevalence in Iceland is not considerable, amounting to about 5 per cent. only. Lastly, it may be mentioned that instances are recorded of the occurrence of the hog-measle (*Cysticercus cellulosæ*) in the dog. Though many have felt sceptical on this point, Gurlt's authority is not to be lightly set aside, confirmed, as it has been, I believe, by MM. Mégnin and Leblanc.

Passing to the round worms it may be said that *Ascaris marginata* is, at the best, a mere variety of *A. mystax* of the cat,

with which must also be placed *A. leptoptera* of the lion and other felines. The lateral appendages not only vary in breadth in these three forms, but also in the specimens obtained from each host. I have encountered examples in a dog, which measured more than six inches in length. The worm is excessively common in England, occurring in probably not less than 75 per cent., whilst in Denmark it occurs in about 24 per cent. According to Krabbe it is rare in Iceland. Its presence is at all times more or less injurious to the bearer, being a frequent cause of sickness, colic, convulsive fits, and paralysis. Occasionally the worms prove fatal to dogs by wandering into the trachea. At the Royal Veterinary College, in 1864, a litter of six puppies, of only three weeks growth, died rather suddenly in consequence of the presence of these worms in the stomach and small intestines. So far back as the year 1684 Redi described round worms from the walls of the œsophagus of a dog. These were afterwards noticed by various observers in tumours of the mucous membrane of the stomach. Owing to their red color, derived from the ingested blood of the host, the species was named *Spiroptera sanguinolenta*. In 1867 I suggested that the minute Filariæ found by Grube and Delafond in the blood of dogs would probably turn out to be referable to this species. The researches of Lewis have proved that this supposition was correct. To be sure, other nematoid hæmatozoa, of microscopic dimensions, occur in the dog, but those described by Grube and Delafond may be referred to *Spiroptera*. These authors estimated their number in the canine host to vary from 11,000 to upwards of 200,000. In one instance Messrs Grube and Delafond found six worms lodged in a clot occupying the right ventricle of the heart. Four were females and two males. Although they were described as representing an altogether new species, which they termed *Filaria papillosa hæmatica canis domestici*, I think there can be little doubt that they were examples of *Spiroptera sanguinolenta* not fully grown. The writings of Lewis abound with interesting details respecting the structure and development of this worm, and as much may be said of the writings of Manson and Welch concerning the cruel threadworm (*Filaria immitis*, Leidy) occupying the right cavities of the heart. I was first made acquainted with this entozoon in 1853, by examining specimens in the possession of Prof. Hughes Bennett of Edinburgh; at which time also I was put in possession of a valuable MS. (since lost) describing

the ravages of this entozoon in the dogs of China. I have since received numerous vermini-ferous hearts both from China and Japan, and also some heart-worms from Charleston, U. S., sent by Mr M'Innes. In a recent communication, Dr Manson has spoken of this worm as if it were comparatively harmless, but all the evidence I long ago received through the late Mr Swinhoe, formerly H. B. M. Consul at Amoy, through Mr Dare's letters enclosing Dr Orton's valuable observations (addressed to the editor of the 'Field'), through the lost MS. above alluded to, through Dr Lamprey's statements, and through many other sources, lead to the very opposite conclusion. No doubt the canine hosts do for a time appear to be little inconvenienced by their nematode guests, but sooner or later the most distressing symptoms set in. As in Hoysted's case (quoted below) the convulsive spasms may occasion death in a few minutes, but frequently they last for hours or days, with more or less prolonged intervals of relief before the final struggle.

FIG. 58.—*Filaria immitis*. Tail of male. Enlarged. Original.

Some other filariform nematodes have been imperfectly described. Of these, Gescheidt's *Filaria oculi canini* (*F. trispinulosa*, Diesing) was probably a sexually-immature worm, and the same may be said of the encysted worms found by Mr Mather in the mucous coat of the intestines and in the liver ducts and acini (*Filaria hepatica*, Cobbold). Of more interest is Leisering's hæmatozoon (*Strongylus subulatus*). These minute worms occupy the veins, the largest females not exceeding $\frac{1}{12}''$ in length. They are viviparous, and thus form another source of embryonic hæmatozoa. A single drop of infected venous blood commonly carries from four to six mature worms. In this place may be mentioned Dr Osler's *Strongylus canis bronchialis*. The largest males measure $\frac{1}{6}''$ and the females fully $\frac{1}{4}''$. In the worms sent to me by Prof. Osler I saw no evidence of strongyloid structure, and in his description he avoids all mention of the presence of any caudal hood in the male. I regard the worms as Filariæ (*F. Osleri*, Cobbold). Very great interest attaches to them from the fact that they produce a destructive canine epizoöty, resembling the ordinary

"husk" or parasitic bronchitis of calves, lambs, and other domesticated animals. The only other genuine strongyle known to infest the dog is *Eustrongylus gigas*. This is a very common parasite in wolves. I have already spoken of this parasite at some length (Book I, p. 207), and can only further refer to the recently published case by Mégnin (quoted below, and at full length in my paper in the 'Veterinarian' for April, 1879). The Museum of the Royal Veterinary College contains three fine examples of this worm coiled within the kidney of a dog, or rather within the renal capsule, for the substance of the organ is almost entirely wanting. These are from Bickford's case.

Amongst the many good "finds" made by Lewis in India, not the least interesting is that appertaining to *Cheiracanthus robustus*. Lewis, indeed, supposed that he had detected *Echinorhynchi* in chestnut-sized tumours of the walls of the stomach, but, as I pointed out at the time, the parasites were entirely destitute of Acanthocephalous structure. As is well known, this curious nematode infests various felines, such as the wild cat, puma, and tiger. In addition to the above canine nematodes we have the wrinkled threadworm (*Trichosoma plica*) infesting the bladder. This is of much more frequent occurrence in the fox. In the list *Trichina spiralis* must also be included, although, so far as I am aware, it has only been seen in dogs that have been subjected to feeding experiments.

Another nematode common to the fox and dogs, and infesting the cæcum, is the whipworm (*Trichocephalus depressiusculus*). It is very rare in the dog. Lastly, there is the important little strongyloid worm generally known as *Dochmius trigonocephalus*. At the hands of Leuckart the general structure and development of this entozoon have received complete elucidation. It infests the small intestines, and is found alike in the fox, wolf, and cheetah. It has also been obtained from *Canis lagopus* and *C. azaræ*. Dr Krabbe did not encounter this worm in Icelandic dogs; nevertheless, he obtained it in a blue fox which died in Kjoerbolling's menagerie, and which had come from Iceland. In Danish dogs it occurred in less than 2 per cent. The embryos of this worm are rhabditiform and possess three long bristle-like teeth, the slender tail being furnished with a distinct appendage at the tip. They develop in moist situations, where they feed freely, grow rapidly, and change their skins, throwing off the caudal tip with the first month. It seems evident that they do not require a change of hosts, since Leuc-

kart succeeded in rearing the sexually-mature *Dochmii* by introducing the rhabditiform larvæ into the stomach of the dog; moreover, his experiments upon water-snails belonging to the genus *Physa* gave negative results.

Of Arachnidan parasites (*Trachearia*) infesting the dog, by far the most interesting is the well-known *Pentastoma tænioides*, shown by Leuckart to be the adult condition of the still better known *Pentastoma denticulatum*. It resides in the nasal sinuses. As already mentioned in a former part of this work, these parasites present four marked stages of growth, namely (1), the embryo, (2) the pupa, (3) the active larva (*P. denticulatum*), and (4) the sexually-mature worm. As the eggs and their embryonic contents are lodged in the nasal mucus of the dog, and are commonly distributed by the act of sneezing on the part of the animal, the sources of infection are not far to seek. Clearly the larvæ usually get introduced to the bodies of mankind and herbivorous animals by the ingestion of unclean vegetable matter. The embryos set free in the stomach bore their way to the liver and other viscera, in which organs encystation and moulting subsequently take place. The fondling of dogs infested by pentastomes may prove dangerous by a more direct transference of the eggs to the hands and mouth. As regards the dog, the adult parasite has been known to prove fatal. A very striking instance of this kind was recorded by Prof. Dick, where the worms wandered into the trachea producing asphyxia.

The ectozoa of the dog, though not numerous as species, are of importance in relation to mange. The follicle-mites form a family by themselves (*Demodicidæ*), and, as already observed, those infesting the dog and cat are, alike, mere varieties of the human species (*Demodex folliculorum*, var. *caninius* and var. *cati*). Whilst the human parasite restricts itself to the face, the canine variety (fig. 52) will occupy any part of the dog's body. The follicle-mite of the cat, however, usually confines itself to the ear. According to Mégnin, to whose beautiful monograph we owe so much, two or three dozen of these parasites may be found occupying a single follicle of the dog. Acne-like pustules are thus formed, and when they are very numerous death may result from the excessive irritation, which is usually accompanied with depilation. An interesting example of this kind recently occurred at the Royal Veterinary College. In regard to the ordinary mange-mite (*Sarcoptes canis*, Gerlach) M. Mégnin points out that it is in all respects identical with the human

itch-insect. In the wolf and fox, however, the same species forms well-marked varieties (*S. scabiei*, var. *lupi* and var. *vulpis*). As regards true insect parasites and tormentors of the dog, I can only allude to a few of them. In tropical America dogs are said to be attacked by the larvæ of a species of gad-fly (*Œstrus canis*), whilst in Africa they are often fatally bitten by the tsetse (*Glossina morsitans*). In addition to the flies (*Diptera*), several kinds of fleas (*Aphaniptera*) frequently prove troublesome (*Pulex canis, P. martis*, and *P. penetrans*), and the same may be said of certain lice (*Hemiptera*). The common louse of the dog (*Trichodectes latus*) proves especially noxious to young puppies. Of the two other species, namely, *Hæmatopinus piliferus* and *H. canis*, the former is tolerably common, whilst the latter is comparatively rare. This species is also found on the ferret. A new form of mite (*Chorioptes ecaudatus*), infesting the ears of the ferret, has recently been described by M. Mégnin.

I have already referred to several of the parasites of the cat-tribe (*Felidæ*), but some others require notice. Only two flukes (*Amphistoma truncatum* and *Hemistoma cordatum*) have been described as infesting the cat. Of the tapeworms, *Tænia crassicollis* is the best known. This is derived from *Cysticercus fasciolaris* of the mouse and rat. It is not uncommon to find this scolex in the sexually-immature tænioid state in the liver, measuring six or seven inches in length. An exceedingly interesting communication by Dr Romano, of Gemona (Frioul), demonstrates the possibility of severe feline epizoöty as due to this entozoon. As I gather from an account given in the journal quoted below, "during the summer of 1876, Dr Romano was informed by his confrère Dr Leoncini, a physician practising at Osoppo, that for about a fortnight most of the cats in a certain hamlet of the town had died without appreciable cause after presenting the following symptoms :—Gradual wasting, with complete loss of appetite, retracted abdomen, slight diarrhœa at first, then constipation, abundant saliva, contraction of the elevating muscles of the upper lip in some subjects, great prostration of strength, loss of the visual faculty. Some of the feline patients no longer heard or appeared no longer to hear their master's voice; some vomited and seemed to experience relief, for the appetite improved, but they soon died like the others. Nervous phenomena, epileptiform convulsions, and more frequently colic, also showed themselves. Having visited the

locality (of the outbreak), Dr Romano could not at first procure any corpses for the post-mortem examination, for the children had thrown them into the Tagliamento, which flows at the foot of the fortress of Osoppo. It was only after the lapse of some days that he was able to open one of the animals which had just succumbed. The principal evils were remarked in the stomach, the walls of which were retracted and formed the seat of a catarrhal inflammation, from the products of which a long, white, flat worm was removed with care for examination. All the other organs were in good condition. The examination of the helminth in the stomach, made with the help of Dr Leoncini and Fachini, showed that the flat worm (white, and with the body divided into rings, 12 centimètres long, and 5 or 6 millimètres broad) had all the characters of the tænias, and this was confirmed by a microscopic examination of the head. A few days later Dr Romano made an autopsy of two other cats. In one of the corpses he noted the alterations described above, and found a tænia smaller than the first; in the other the same lesions without any helminth. This negative circumstance very naturally disconcerted Dr Romano, but several people of the place came to assure him that they had seen their cats, during the course of the malady, after violent and repeated efforts at vomiting, throw up a sort of white cord, which they recognised as corresponding with the tænia he showed them. Thus confirmed and reassured in his diagnosis, Dr Romano sought to identify the species." In this connection it is specially interesting to note that "during the whole summer the inhabitants of Osoppo had been over-run by bands of rats proceeding from the fortress. They were combated by means of cats, and it was the best hunters among the felines that succumbed. Here was, therefore, a striking relation of cause and effect which could not be gainsayed." Dr Romano communicated his observations to the National and Royal Veterinary Society, but by an error in the report the species appears to have been described as *Tænia tenuicollis* instead of *T. crassicollis.* In this connection I have only further to add that the wild cat is infested by a tapeworm scarcely an inch in length (*Tænia lineata*). A species of Bothriocephalus (*B. decipiens*) likewise infests the domestic cat, in common with most of the wild felines, such as the tiger, puma, ounce, and jaguar. Dr Bancroft brought me a specimen from an Australian cat. The nematodes of the cats are very

abundant. Dr Bellingham found a trichosome (*T. felis cati*) in the urinary bladder of the wild cat. This is probably identical with *T. plica.* A tolerably common nematode is *Dochmius tubæformis,* which occurs not only in the cat but also in the leopard, puma, jaguar, ounce, panther, and also in *Felis tigrina* and *F. mellivora.* In the last-named and in other Brazilian felines an echinorhynchus (*E. campanulatus*) was found by Natterer. A strongyle (*Sclerostoma dispar*) infests the lungs of the puma. A species of spiroptera (*S. subæqualis,* Molin) infests the œsophagus and stomach of the lion and tiger. Redi also noticed a species of Filaria beneath the skin of the lion. *Physaloptera terdentata* (Molin) and *P. digitata* (Schneider) infest the stomach of the puma. I can only allude also to *Tænia laticollis* of the lynx, *Pentastoma recurvatum,* occupying the frontal sinuses and air-passages of the ounce, and *Ligula reptans* the subcutaneous tissues of the leopard. Lastly, there is the *Olulanus tricuspis* of the domestic cat. I have examined the lungs of three cats containing this parasite, which was first described as an entirely new species by Leuckart. The adult worms, only $\frac{1}{25}''$ in length, occupy the walls of the stomach. Thence they are apt to migrate or stray into the lungs and liver, where they encyst themselves. When myriads of them are thus encysted a kind of nematode tuberculosis is set up. This disease I have elsewhere called *olulaniasis.* Ordinarily, however, the encysted condition of *olulanus* is to be found in the muscles of mice, which are thus said to be olulanised. Clearly, as Leuckart's experiments substantially prove, the domestic cat acquires the adult worm by catching and devouring olulanised rodents. Every now and then the disorder thus created produces a virulent and fatal feline epizoöty.

Bibliography (No. 45).—(Anonymous), "Curious Note on two Tænia from the Dog (asserting that neither strong whisky nor boiling water would kill them)," 'Med. Commentaries,' vol. xvi, p. 370, 1791.—*Araujo, A. J. P. S.,* "A *Filaria immitis* e *F. sanguinolenta* no Brazil," 'Gazeta Medica da Bahia,' Julho de 1878.—*Baillet, C.,* "On Dochmius, and on a Worm found in the Heart and Vessels of a Dog," from 'Journ. Vet. du Midi,' in the 'Veterinarian,' p. 549, 1862.—*Baird, W.,* "Note on the *Spiroptera sanguinolenta* found in the Heart of Dogs in China," 'Proc. Linn. Soc.,' vol. ix, Zool. Div., p. 296, 1867.—*Balbiani* (l. c., Bibl. No. 28).—*Beneden* (see Van Beneden, below).—*Bickford* (l. c., Bibl. No. 28).—*Chapman,*

" On *Ascaris mystax* (leptoptera) in the Tiger and American Wild Cat," 'Proc. Acad. Philad.,' 1875, pp. 14 and 17.—*Cherry, E. F.*, " Worms in the Stomach of a Dog," in the 'Farrier and Naturalist,' 1829, vol. ii, p. 303.—*Clamorgan, J. de*, " Serpents dans les reins," in his 'La Chasse du Loup,' 1570; see also Bibl. No. 28.—*Cobbold*, " On the Prevalence of Entozoa in the Dog, in relation to Public Health," 'Journ. Linn. Soc.,' vol. ix (Zool. Sect., No. 37, p. 281), 1867; also in 'Lancet,' April 27, 1867, p. 521; and in supp. to 'Entozoa,' 1869.—*Idem*, " Observ. on Entozoa, with experiments in regard to *Tænia serrata* and *T. cucumerina*," 'Linn. Trans.,' 1858.—*Idem*, " On some new Forms of Entozoa," 'Linn. Trans.,' 1859.—*Idem*, " Further Observ. on Entozoa, with Experiments," 'Linn. Trans.,' 1861. —*Idem*, " On *Filaria immitis*," 'Proc. Zool. Soc. of Lond.,' Nov. 18, 1873, p. 736.—*Idem*, " Observ. on Hæmatozoa," in the 'Veterinarian,' Oct., 1873.—*Idem*, " Parasites of the Dog," in 'Manual,' 1874, l. c., chap. ix, p. 86.—*Idem*, " Description of a new generic type of Entozoon (Acanthocheilonema) from the Aard Wolf (Proteles)," 'Proc. Zool. Soc. of Lond.,' Jan. 13, 1870.—*Idem*, " On *Distoma compactum*," in 'Linn. Trans.,' vol. xxii, p. 363, 'Proc. Zool. Soc.,' March, 1861.—*Idem*, various letters on " Canine Epidemics in relation to Lumbricoid Worms in Dogs," in the 'Field,' Dec., 1872.—*Idem*, " Remarks on the Life-epochs (biotomes) of *T. cœnurus* and *T. echinococcus*," in a paper on 'Animal Individuality,' 'Journ. Linn. Soc.,' Zool. Div., vol. viii, p. 163.—*Idem*, " Worms in the Heart (Mr. M'Innes' specimen from Charleston)," the 'Veterinarian,' Feb., 1875.—*Idem*, " Note of Lewis' Discoveries," in 'Nature,' March 11, 1875, vol. ii, p. 363.—*Idem*, " Remarks on *Eustrongylus gigas*" in the 'Veterinarian,' April, 1879.—*Coles, E. C.*, " Worms in the Heart and Œsophagus of a Dog," 'Path. Soc. Rep.,' March, 1878.—*Dare, J. J.*, " Death of Dogs from Worms in the Heart," the 'Field,' Feb. 24, 1872.—*Davaine*, 'Traité,' l. c., 2nd edit., p. 290 (for refs. to lit. of *Strongylus gigas*).—*Delafond* (with *Grube*), " Note on a Verminiferous kind of Blood of a Dog, caused by Hæmatozoa of the genus Filaria," from 'Ann. de Chimie et de Physique,' in 'Ann. of Nat. Hist.,' vol. xi, 1843, and 'Comp. Rend.,' in 'Lond. Phys. Journ.,' p. 28, 1843; also from 'Gaz. Med.,' in 'Med.-Chir. Rev.,' vol. xxxv, p. 393, 1843–44; see also 'Edin. New. Phil. Journ.,' vol. lii, p. 233, 1852, and 'Veterinarian,' vol. xviii, p. 216, 1845.—*Dick*, " Worms the cause of Sudden Death in a Dog," the 'Veterinarian,' vol. xii,

p. 42, 1840 (Pentastomes).—*Diesing*, 'Syst. Helm.,' vol. ii, p. 327 (Eustrongylus).—*Ercolani, G. B.*, "Osservazione elmintologiche sulla dimorfobiosi nei Nematodi, sulla *F. immitis* e sopra una nuova specie di Distoma dei cani," 'Mem. Accad. Bologn., v, 1874–5.—*Frank* (see Bibl. No. 28).—*Gay, J.*, Specimen of Olulanus in Hunterian Museum, and marked in the 'Catalogue' "No. 1814A, Lung of Cat, pneumonic, from the presence of parasites."—*Gay*, "Nematodes of Panther," in 'Hering's Repert.,' 1873, from 'Il. Med. Vet.'—*Herbst*, "On Trichinæ in the Badger," from 'Ann. des Sci. Nat.,' in 'Assoc. Med. Journ.,' 1853, vol. i, p. 491.—*Hoysted* (and *Sir J. Fayrer*), "On *Filaria sanguinis* (really *F. immitis*)," 'Lancet,' March 1, 1879, p. 317.—*Jamieson* (see Manson).—*Jardine* (see Manson).—*Klein, J. T.*, "Worms found in the Kidneys of Wolves," 'Phil. Trans.,' vol. xxxvi, 1729.—*Krabbe*, "Husdyrenes Involdsorme," 'Tidsskrift for Veterinairer,' 1872. — *Leblanc*, "Subcutaneous Tumour in the Dog, due to the presence of *Strongylus gigas*," from 'Recueil de Méd. Vét.,' in 'Edin. Vet. Rev.,' Dec., 1863; see also Bibl. No. 28.—*Idem* (see Mégnin).—*Legros*, "Hæmatozoa of Dogs," in 'Rec. de Méd. Vét.,' i, p. 947.—*Leisering*, "On *Hæm. subulatum*," in 'Virch. Archiv,' 1865. — *Leuckart* (see Bibl. Nos. 28, 29). — *Idem*, (for development of *T. serrata*, &c.), 'Die Blasenbandwürmer und ihre Entwicklung,' Giessen, 1856.—*Idem*, 'Bau und Entwicklungsgeschichte der Pentastomen (especially *P. tænioides* and *P. dent.*),' Leipzig, 1860.—*Idem*, 'In relation to the genus Dochmius,' see his standard work, l. c., s. 433, and also 'Arch. f. Heilkunde,' Bd. ii, s. 212 (see also *Parona*).—*Lewis, T. R.*, "On Nematoid Hæmatozoa of the Dog," 'Quart. Journ. Micr. Soc.,' 1875, vol. xv.—*Idem*, "On *Filaria sanguinolenta*, Echinorhynchus, &c., from the Dog," in his oft-quoted 'Memoir,' Calcutta, 1874.—*Linstow, O. von*, "Ueber die Muskulatur, Haut und Seitenfelder von *Filaroides mustelarum*, v. Ben.," 'Arch. f. Naturg.,' xl, s. 135 (with figs.).—*Idem*, "Einige neue Nematoden," &c., 'Arch. f. Naturg.,' p. 293, Bd. xxxix.—*Manson, P.*, "On *F. sanguinolenta* and *F. immitis*," in his 'Report on Hæmatozoa,' in the 'Customs Gaz.,' No. xxxiii (with numerous figs.), Jan.–March, Shanghai, 1877. (N.B.—The same journal, Rep. No. 12, Gaz. No. xxx, contains remarks on worms in the heart of dogs by Dr A. Jamieson. The subject is also discussed by Dr Jardine.) See also 'Med. Times and Gaz.,' Oct. 20, 1877, p. 480.—*Mather, T.*, "Filariæ found in the

Intestines of a Dog," 'Veterinarian,' vol. xvi, p. 434, 1843.—*McConnell*, "On *D. conjunctum*," 'Lancet,' March 30, 1878, p. 476.—*Mégnin, P.* "On Myobia," 'Abhandl. ueber eine neue Gruppe von Acariden (u. s. w.),' in 'Revue f. Thierheilkunde,' Oct., 1878, p. 149.—*Idem*, "Sur un parasite des oreilles chez le furet," 'Rec. de Méd. Vét.,' Oct., 1878.—*Idem* (avec *C. Leblanc*), "Note sur le *Cysticercus cellulosæ* developpé chez le chien," 'Bullet. de la Soc. cent. vét. de Paris,' 1873.—*Idem*, "Sur le *Strongylus gigas*," Bullet. de la Société Entom. de France, No. 3, 1879.—*Melnikow, N.*, "On *Tænia cucumerina*," in 'Arch. f. Naturg.,' 1869, p. 62.—*Miller, E.*, 'Six Cases of Strongyle in the Kidney of *Putorius vison*' (quoted by Davaine from Museum of Boston, U.S.).—*M'Innes* (see Cobbold).—*Molin*, 'Nuovi myzelmintha,' s. 34, 1859.—*Idem*, 'Una monog. del gen. Physaloptera (*P. terdentata*),' 1860, s. 17.—*Idem*, 'Una monog. del gen. Spiroptera (*S. subæqualis*),' 1860, s. 13.—*Nettleship, E.*, "Notes on the Rearing of *Tænia echinococcus* in the Dog from Hydatids, with some observations on the anatomy of the adult worm," 'Proc. Roy. Soc.,' 1866, No. 86, p. 224, with figs.—*Noseda, B.*, "Six Strongyles in the Kidney of the Agouara-gouazura or Puma," in Don F. de Azara's 'Quadrupèdes du Paraguay,' Paris, 1801 (see also Azara, Bibl. No. 28).—*Osborne, T. C.*, "Worms found in the Heart and Blood-vessels of a Dog (with symptoms of hydrophobia)," 'Western Med. Journ.,' rep. in 'Bost. Med. and Surg. Journ.,' vol. xxxvii, p. 448, 1847–48.—*Osler, W.*, "Verminous Bronchitis in Dogs (from Strongyles)," 'Veterinarian,' June, 1877, p. 387.—*Owen*, "On the Anatomy of *Linguatala tænioides*," 'Trans. Zool. Soc.,' vol. i, 1835, and in 'Lond. Med. Gaz.,' 1835.—*Idem*, "Anatomical description of two species of Entozoa, from the Stomach of a Tiger, one of which forms a new genus, Gnathostoma," 'Proc. Zool. Soc.,' part iv, 1836.—*Parona* (and *Grassi*), "On a new Species of Dochmius (*D. balsami*)," 'Reale Instituto Lombardo di Scienze e Lettere, Rendiconti,' vol. x, fasc. vi, 1877.—*Raynold, T. M.*, "Tapeworm in the Pointer and Spaniel," 'Veterinarian,' vol. xiv, p. 694, 1841.—*Romano*, "Epizoöty amongst Cats from *Tænia crassicollis*," 'Giornale di med. vet. practica,' Août, 1877, and in 'Journ. de Méd. Vét.,' Avril, 1878.—*Schuppert, M.*, "Mechanical Obstruction of the Heart (of a Dog) by Entozoa, causing Death," 'New Orleans Med. News and Hosp. Gaz.,' Jan., 1858, also 'Bost. Med. and Surg. Journ.,' vol. lvii, 1857–58, and in 'Med.-Chir. Rev.,'

1858.—*Stirling*, "On the Changes produced in the Lungs by the Embryos of *Olulanus tricuspis*," 'Quart. Journ. Micr. Sci.,' 1877, p. 145.—*Van Beneden*, "On the Transmigration of the Entozoa" (in answer to MM. Ponchet and Verrier), from the French, by Busk, in 'Quart. Journ. Micr. Sci.,' 1862.—*Idem*, "Researches on the Intestinal Worms," from Van der Hoeven's abstr. in the 'Nederlandsch Tijdschrift voor Geneeskunde,' in 'Ann. Nat. Hist.,' vol. iii, 3rd ser., 1859.—*Idem*, "New Obs. on the Development of the Intestinal Worms," from 'Compt. Rend.,' in 'Ann. Nat. Hist.,' vol. xiii, 2nd ser., 1854.—*Idem*, "On *Filaroides mustelarum*," 'Mém. sur les vers intest.,' 1858, p. 267.—*Welch*, "On *Filaria immitis*," 'Lancet,' March 8, 1873; also in 'Month. Micr. Journ.,' Oct., 1873, p. 157 (with three plates).—*Wilson, W.*, "A Parasitic Worm infesting the Air Sinuses of the Weasel," 'Midland Naturalist,' May, 1878.—*Wright*, "On Worms found in the Pulmonary Artery of a Dog," 'Lancet,' 1845, and in 'Veterinarian,' vol. xviii, p. 52, 1845.—*Youatt*, "On Tumours (containing Entozoa) in the Stomach of a young Tiger," 'Veterinarian,' vol. x, p. 619, 1837; see also Owen on 'Gnathostoma.'—*Idem*, "Worms (*Ascaris marginata*) in the Nose of a Dog," 'Veterinarian,' vol. v, p. 337, 1832.

PART V (Pinnipedia).

Following the order of classification adopted in my description of the Mammalia in the 'Museum of Natural History,' I proceed to speak of the internal parasites of the seals (*Phocidæ*) and walruses (*Trichecidæ*). From their piscivorous habits one would naturally expect the seals to be largely infested with entozoa, and yet, though sufficiently victimised, they are not liable to entertain so great a variety of helminths as the fishes themselves on which they feed.

The flukes observed in *Phoca vitulina* are *Distoma acanthoides* and *Amphistoma truncatum*, the latter occurring also in *P. grœnlandica*. In another seal (*P. barbata*) we have *D. tenuicolle*. The nematodes are more numerous. The best-known is the maw-worm (*Ascaris osculata*), which seems to be always present in full-grown seals of every kind. In the years 1862-64 I conducted a series of experiments with the eggs of this worm. I reared embryos both in salt and fresh water, but the administration of the young worms to various animals led to no result.

However, I succeeded in watching the growth of the embryos until they had acquired well-marked digestive organs and a length of $\frac{1}{25}''$, their size when emerging from the egg-shell in the water having been about $\frac{1}{150}''$ only. The large strongyle (*Eustrongylus gigas*) has been found in various organs of the common seal. Of more interest are the *Filariæ* found in the heart of seals, which in many respects resemble those obtained from the same situation in dogs. Professors Joly, Leidy, and myself, have each described a species, but apparently our descriptions all refer to one and the same parasite. It has also been seen by Camill Heller. The close correspondency in size and other characters of Leidy's *Filaria spirocauda* and my *Filaria hebetata* leaves little doubt as to their identity. As the worms were both originally noticed by Leidy and Joly in 1858, I cannot pronounce upon the question of priority of discovery. By Joly the worm was called *F. cordis phocæ*. In Leidy's and in my own specimens the males were four inches long, and the females six inches; they extended up to 8″ in some of the American examples. The worms found by Prof. Joly were all females. Professor Millen Coughtrey, who furnished me with the seal's heart, stated that it was obtained from a male hoodcap (*Stemmatopus cristatus*), a rare visitant of our British coasts. This seal was captured on the Cheshire side of the Mersey river. Leidy and Joly obtained their specimens from *Phoca vitulina*. In the common seal have also been found *Ligula crispa*, *Schistocephalus dimorphus*, and *Echinorhynchus strumosus*. In other seals a not uncommon tapeworm of the Bothriocephalous type is that called *Dibothrium hians* by Diesing. To Prof. Krabbe I am indebted for a specimen of *Bothriocephalus fasciatus* taken from *Phoca hispida*. There is a nematode of frequent occurrence in *P. hispida* and *P. grœnlandica*. This is the *Ophiostoma dispar* of Rudolphi. In addition to the above I can only add that *P. barbata* is infested by *Liorhynchus gracilescens*, occupying the stomach, and by a tapeworm, *Tetrabothrium anthocephalum*, which is found in the lower part of the large intestine.

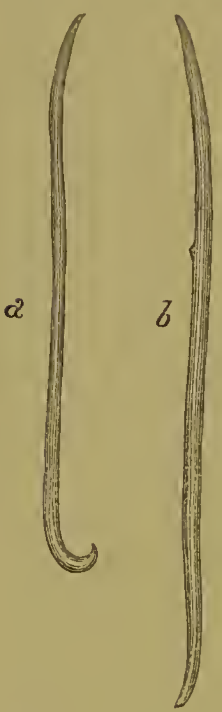

FIG. 59.—*Ascaris osculata*. *a*, Male; *b*, female. Natural size. Original.

BIBLIOGRAPHY (No. 46).—*Cobbold*, "Description of *F. hebetata*,"

in 'Notes on Entozoa,' part i, sp. 3, 'Proc. Zool. Soc.,' Nov. 18th, 1873, p. 741.—*Idem*, "On *Ascaris osculata*," in 'Report of Experiments respecting the development and migrations of the Entozoa;' 'Brit. Assoc. Trans.,' 1864, p. 114.—*Heller, C.*, in 'Schrift der zool.-botan. Gesellsch.,' Wien, 1858, s. 83.—*Joly*, "On a new Species of Hæmatozoon of the genus *Filaria*, observed in the heart of a seal;" from 'Compt. Rend. Acad. Sci.,' 1856, p. 403, in 'Ann. Nat. Hist.,' vol. i, 3rd ser., 1858; also abstr. in the 'Year Book,' 1859.—*Leidy, J.*, (*E. spirocauda*) in 'Proc. Philad. Acad.,' 1858, p. 112.

PART VI (Rodentia).

Though very numerous, the parasites of this order are chiefly interesting as embracing those of the hares and rabbits, moles, mice, rats, squirrels, and beavers. Some slight notice, however, will be given of the entozoa of each of the eleven families into which the order may be divided.

The squirrels (*Sciuridæ*) are liable to be infested by the common liver fluke (*F. hepatica*), and also, it is said, by a cysticercus (*C. tenuicollis*). I have never encountered this bladder worm, but in 1864 I described some polycephalous hydatids (*Cœnuri*) which I obtained from the viscera of an American squirrel. I think the host was of the same species (*Sciurus vulpinus*) as that from which Mr Chapman has since obtained an example of Echinorhynchus (*E. moniliformis*). This worm also infests the hamster. A very small female round worm, probably a strongyle, was described by Rudolphi as *Ascaris acutissima*. It infests the cæcum of the common squirrel, in which host a species of tapeworm is tolerably frequent (*Tænia dendritica*). The common European marmot is infested by *T. pectinata*, so abundant in hares and rabbits. I have also noticed it as occurring in the Canadian porcupine (*Hystrix dorsata*). The dormice (*Myoxidæ*) are not much troubled with parasites, at least I have not encountered any in our common *Myoxus avellanarius*. In *M. glis*, however, a tapeworm, and at least one species of strongyle (*S. gracilis*), have been observed. Dujardin described very fully another strongyle (*S. lævis*) from *M. nitela*, from the long-tailed field-mouse (*Mus sylvatica*), and from *Arvicola subterraneus*. The other species are *Trichosoma myoxi nitelæ*, and *Ophiostoma cristatum* from

Myoxus dryas, and *M. muscardinus*. The jerboas (*Dipodidæ*), in common with the hamster and several species of true mice, are apt to be infested by *Ascaris tetraptera;* and a small nematoid, apparently immature, was noticed by Otto in the intestines and in the abdominal walls and cavity of *Dipus tetradactylus*. Mice, properly so called, are largely infested, as is also the hamster (*Cricetus vulgaris*), which I include in the *Muridæ*. In addition to the parasites already mentioned, the hamster is infested by *Tænia straminea*. Along with examples of this tapeworm I have received from Dr Murie some acephalocysts found in a hamster which died at the Zoological Gardens.

Flukes exist in the long-tailed field-mouse (*Distoma vitta* and *D. recurvum*), but I have not seen any in our common mice and rats. However, Dujardin describes a distome (*D. spiculator*) in the brown rat (*Mus decumanus*). One of the tapeworms observed in the mouse (*M. musculus*) is *Tænia pusilla*, also found in the rat (*M. rattus*) and long-tailed field-mouse. The house-mouse likewise harbors *T. microstoma* and *T. leptocephala;* and an immature cestode has also been seen in the abdomen, probably a species of *Ligula*. Various species of rat also harbor *T. diminuta*. In regard to the round worms one of the most common species is *Ascaris oxyura*. This not only occurs in rats and mice, but also in voles, water-rats, and many other rodents. The rodents' whipworm (*Trichocephalus nodosus*) is yet more common in the lemmings, rats, voles, and mice; another species (*T. unguiculatus*), taking its place in hares and rabbits, and yet another (*T. affinis*) in the porcupine. Another nematoid, very common in mice, is *Spiroptera obtusa*, occupying the stomach. I have seen a mouse with its abdomen so distended by their presence that the animal could scarcely run along the pathway where it was killed by being trod upon. According to Marchi, the young of this entozoon dwell in the fat surrounding the alimentary canal of the larva of an insect (*Tenebrio molitor*). When noticing the parasites of the cat I referred to Leuckart's interesting discovery of the relations subsisting between the adult *Olulanus tricuspis*, found in the stomach walls of that feline, and the immature encysted worms, found not only as wanderers in the cat itself but also in the muscles of mice. The olulanised mouse is thus an intermediate host. Rats and mice also play the part of intermediary bearers in the case of two other species of entozoa, namely, *Trichina spiralis* and *Tænia crassicollis*, the tænioid scolex or larval

condition of the cat's tapeworm being familiarly known as *Cysticercus fasciolaris*. This sexually-immature tapeworm infests many other rodents, especially the voles (*Arvicolidæ*). In regard to *Trichinæ* it must not be forgotten that their presence in rats is not uncommon in some parts of Europe; and this circumstance may explain the recurrence of trichinosis (first in hogs and then in man) in certain outlying districts. Only in this way can the Cumberland outbreak in this country be accounted for. Here I cannot dwell upon the subject, but in this connection I may observe that Bakody has in a very convincing manner described a new variety or species of Trichina, found by him infesting the walls of the stomach and intestine of rats. In the first instance he detected the worm in association with the ordinary *T. spiralis*, but afterwards separately. He also obtained it in fowls. The species should be called *Trichina Bakodyii*. Possibly the nematodes observed by Colin in 1863 also refer to this worm. They occupied tubercles in the liver of a rat. In regard to the beavers (*Castoridæ*) it appears that they harbor many species of round worms, and also several flukes, but they do not appear to have been very much studied. In Morgan's work on the American beaver there is a notice in which it is stated that Dr Ely found a very fine filamentous worm 40‴ in length. This does not seem to correspond with *Ascaris castoris* (Rud.). He also speaks of large numbers of a slender white worm, 3″ to 5″ in length, found in the peritoneal cavity, and referable to the genus *Filaria*. This cannot be confounded with *Trichocephalus castori* (Rud.). Moreover, he describes a strongyle (*Sclerostoma*) as infesting the colon, and especially the cæcum. These all appear to be new to science. The *Fasciola hepatica* is occasionally found in the liver, but the most common helminth of beavers is *Amphistoma subtriquetrum*. Specimens of this worm may be seen in the British and Hunterian Museums. As regards the porcupines (*Hystricidæ*) I have already mentioned the occurrence of a tapeworm in the common species. The larval *Pentastoma denticulatum* has been found by Otto attached to the surface of the lungs, and Redi, about two centuries back, noticed small nematodes lodged in tubercles of the œsophagus. The late C. M. Diesing obtained *Trichocephalus affinis* from the intestines. So far as I am aware, little or nothing has been said respecting the helminths of the *Octodontidæ*, *Chinchillidæ*, and *Cavidæ*. Like other European

investigators I have dissected guinea pigs (*Cavia aperæa*) without finding any parasites; but in Brazil a small species of ascaris (*A. uncinata*) was found by Natterer in this animal and also in the paca (*Cœlogenys paca*) The agoutis (*Dasyprocta*) harbor *Trichocephalus gracilis*.

The entozoa of the duplicidentate rodents (*Leporidæ*) acquire importance from the fact of their abundance and from the intimate relation which some of them bear to parasites infesting the dog and other animals. Thus, the two commonest kinds of fluke infesting cattle (*Fasc. hepatica* and *Dist. lanceolatum*) also attack hares and rabbits; the former parasite often producing the rot disease, which is almost as fatal to the rodents as it is to the ruminants. Mutual infection occasionally results from this circumstance by the distribution of germs. All experiment-conducting helminthologists have reared *Tænia serrata* from the *Cysticercus pisiformis*; nevertheless, several English Manuals of Zoology persist in propagating the old error of Von Siebold, who supposed he had reared this tapeworm by the administration of Cœnuri. So far as I am aware, no feeding experiments have been conducted with the Cœnuri of rabbits (*C. cuniculi*). These bladderworms infest the soft parts of the body, often producing tumours having a very unsightly appearance. For details I must refer to the papers quoted below. The Norfolk warreners call the infested hosts "bladdery rabbits." Though apparently most abundant in the eastern counties of England, these diseased rabbits are by no means confined to that quarter. Through Mr Alston's help I have received specimens of *Cœnurus cuniculi* from Ayrshire, Scotland. Probably this form of Cœnurus occurs wherever rabbits live. In Italy a case is recorded by Perroncito from the abdominal cavity of a rabbit (*coniglio*). Every experimenter is more or less familiar with the cestode larvæ (*C. pisiformis*) found wandering in the abdominal cavity. These were regarded as flukes by Kuhn (*Monostoma leporis*). I need hardly remark that the developmental and structural changes undergone by these Cysticerci during their residence within the rabbit have been exhaustively followed out and treated of by Leuckart. Without dwelling on this subject, I must in justice add that in this relation the special labors of Küchenmeister, Van Beneden, Haubner, Wagener, Röll, Eschricht, and Möller played no inconspicuous part. My own efforts in 1857, and subsequently, were not unattended with success. It

therefore seems to me, without prejudice to the recent experiences of De Sylvestre and others, that further experiments in this immediate connection are unnecessary. As regards the nematodes of leporine rodents, probably the most important is *Strongylus commutatus.* This parasite, like its husk-producing congeners, infesting calves and lambs, occasionally sweeps off great numbers of hares. Such an epizoöty occurred in Thuringia in 1864. The most frequent intestinal parasite of rodents is probably *Oxyuris ambigua,* but *Strong. retortæformis* is tolerably abundant in the hare, and *Trichocephalus unguiculatus* is liable to occur in all leporines. I know nothing of the so-called *Strong. strigosus* of rabbits, but Bellingham found it in Ireland. Olfers and Natterer obtained a small ascaris (*A. veligera*) from *Lepus braziliensis;* but I cannot help thinking that the large measle (*Cysticercus macrocystis*) described by Diesing as three inches in length, and obtained from the same rodent, must either have been *Cœnurus cuniculi* or else another form of polycephalous hydatid.

In reference to the ectozoa of rodents it may be said that they are very numerous. Acari infest rats and mice, and especially leporines. Thus, in the mouse are found *Sarcoptes notoedre,* Bourguignon, var. *muris,* Mégnin, *Sarc. musculinus,* Koch, and *Myobia musculi,* Claparède. It is not very generally known that wild rabbits are apt to be attacked by the common autumnal spider (*Leptus autumnalis*), whence, as once happened with myself, they may be transferred to the human body. The ears of tame rabbits are sometimes covered with acari, which are easily destroyed by the cautious application of a mixture of carbolic acid and olive oil (one of acid to six of the oil). Rodents also harbor fleas. At a meeting of the Entomological Society in 1875 Mr Vernall showed living specimens from the ears of a rabbit, and Messrs Cole and W. A. Lewis stated that they had obtained fleas from the hedgehog and European marmot respectively.

Bibliography (No. 47).—*Beneden* (see Van Beneden below).—*Capelle, J.,* Extr. from a letter, in which the author states that he had "found worms of the tænia kind in the liver of sixteen out of eighteen rats," 'Med. Commentaries,' vol. xix, p. 139, 1794; see also 'Trans. Coll. Phys. of Philad.,' vol. i, part ii, p. 60, 1793.—*Chapman, H. C.,* "Echinorhynchus in Squirrel," 'Proc. Acad. Philad.,' 1874, p. 76.—*Cobbold,* "Note on Cœnurus (from a squirrel)," 'Proc. Linn. Soc.,' May 5, 1864.—*Idem,* "On the

occurrence of *Tænia pectinata* in the Porcupine (*Hystrix dorsata*)," in a letter to Dr. Lawson in the 'Canadian Naturalist and Geologist,' 1862.—*Idem*, 'On *T. serrata*,' &c. (see Bibl. No. 45). —*Colin*, "On the presence of a Nematode Worm in certain Tubercles of the Liver of a Rat," from 'Rec. de Méd. Vét.,' in 'Edin. Vet. Rev.,' Oct., 1863.—*Leuckart*, 'Die Blasenbandwürmer (u. s. w.),' 1858 (contains numerous details and figs. in ref. to *Cysticercus pisiformis* and *T. serrata*, &c.).—*Marchi, P.*, 'Mem. della R. Accad. d. Sci. di Torino,' xxv.—*Peacock*, "Remarks on the Liver of a Mouse with Cysts containing Cysticerci," 'Lancet' and 'Trans. Path. Soc.,' 1855.—*Perroncito, E.*, "Sopra un caso di Cœnurus (in the abdominal cavity of a rabbit)," 'Giornale Med. Veter.,' 1876.—*Siebold* (see Von Siebold, below).—*Sylvestri, De*, "Experiments with *C. pisiformis*," 'Il. Med. Veterinario,' 1871.—*Van Beneden* (see Bibl. No. 45).—*Idem*, "On *Sciurus glacialis* and its Parasites," from 'Bull. de l'Acad. de Belgique,' in 'Ann. Nat. Hist.,' vol. xiii, 1854.—*Verrall*, in 'Proc. Ent. Soc. Lond.,' Feb. 15, 1875, p. 3. —*Von Siebold*, 'Ueber die Band- und Blasenwürmer,' Leipsig, 1854, and Huxley's edit. for Syd. Soc., 1857.—*Idem*, "Experiments on the Transformation of the Cystoid Worms into Tænias," from 'Ann. des Sci. Nat.,' in 'Ann. Nat. Hist.,' vol. x, 1852.—*Idem*, "Helminthology," trans. by Busk and pub. in 'Ray Soc. Rep. on Zool.,' 1843–44, p. 446, London, 1847.—*Idem*, "On the Transformation of *Cysticercus pisiformis* into *Tænia serrata*," from 'Zeitsch. f. w. Zool.,' in 'Quart. Journ. Micr. Sci.,' 1854.

Part VII (Edentata).

The entozoa of the edentulate mammals are not very numerous. So far as I am aware only one species has been described from the scaly ant-eaters (*Manidæ*). This is the small and probably immature ascaris noticed by Whitefield in the walls of the stomach of the badgareit or short-tailed pangolin (*Manis pentadactyla*). Amongst the true ant-eaters (*Myrmecophagidæ*) a single round worm has also been observed, but not adequately described. I allude to Marcgrav's "find" in the little ant-eater (*Myrmecophaga didactyla*). I observe that Rudolphi distinctly refers to this edentate as the tamandua. Diesing does the same. The ant-eaters are much infested by a

thorn-headed worm (*Echinorhynchus echinodiscus*). On the 1st November, 1875, I received from Prof. Flower a jar labelled as follows: "Entozoon found attached to intestine of tamandua ant-eater." The parasite was procured from the society's gardens on August 12th, 1871. Natterer originally obtained this worm from *Myrmecophaga jubata* and *M. bivittata*. Creplin described it from a *M. didactyla* from Surinam ('Wiegmann's Archiv,' 1849). I presume that *M. tamandua* answers to the *M. bivittata* of Geoffroy, as well as to the tridactyle and tetradactyle species of Linnæus. The parasite in question was a female, measuring exactly 10 inches long, and had its proboscis firmly anchored within the gut. The armadillos (*Dasypidæ*) entertain a variety of nematodes. In 1858 I obtained several examples of *Ascaris retusa* from the rectum of a poyou or weasel-headed armadillo (*Dasypus sexcinctus*). The worm was first procured by Natterer from the black armadillo (*D. peba*), which host also harbors *Pentastoma subcylindricum*. According to the "finds" of Natterer and the subsequent descriptions by Diesing, the two most common helminths of the Brazilian armadillos are *Aspidocephalus scoleciformis* and *Trichocephalus subspiralis*. As regards the sloths (*Bradypidæ*) it would seem that they are particularly liable to entertain round worms. The Ai (*Bradypus tridactylus*) is infested by *Strongylus leptocephalus*, *Spiroptera gracilis*, *Sp. anterohelicina*, and *Sp. brachystoma;* whilst the unau (*Cholœpus didactylus*) harbors the last-named species and also *Sp. spiralis*. All these worms have been described by Molin, and, with the exception of the two first named, were new to science when he wrote his well-known monograph on the genus. They were collected by Natterer. All the species infest either the stomach or intestines, with the exception of *Sp. spiralis*. This singular worm, like the closely allied *Sp. helicina*, infesting the feet of birds, has the habit of coiling itself amongst the tendons of the digits of the hind limbs more especially.

FIG. 60.—Tail of the male *Ascaris retusa*. Enlarged. Original.

BIBLIOGRAPHY (No. 48).—*Cobbold*, "On some new Forms of Entozoa," 'Linn. Trans.,' vol. xxii, p. 365, 1859.—*Idem*, "List of Entozoa," &c., 'Proc. Zool. Soc.,' March 26, 1861.—*Idem*, "Notes on Entozoa," part iii, 'Proc. Zool. Soc.,' Feb. 1, 1876, p. 202.—*Marcgrav*, in his 'Historia rerum nat. Brasil.,' 1648,

p. 226, and in 'Rudolphi's Synopsis,' p. 186.—*Molin*, "Una Monografia del gen. Spiroptera," 'Aus dem Sitzungsb. d. m.-nat. Cl. d. k. Akad. d. Wissensch.,' Bd. xxxviii, 1859, s. 911, Wien, 1860.—*Whitefield*, in 'Edin. New. Phil. Journ.,' edited by Jamieson, 1829, p. 58.

Part VIII (Ruminantia).

In the matter of parasites this order of mammalian animals stands second in importance. An entire volume of the dimensions of the present would barely do justice to the subject. Although in the article "Ruminantia" in 'Todd's Cyclopædia,' and in my popular treatise on the mammalia, I have described the oxen (*Bovidæ*) and sheep (*Ægosceridæ*) as separate families, I shall here speak of their entozoa together; and, at the same time, I shall introduce occasional reference to the helminths of the antelopes and gnoos (*Antilopidæ*), also of the giraffes (*Camelopardidæ*), the deer tribe (*Cervidæ*), the camels, and the llamas (*Camelidæ*). The parasites of the last family, however, will necessarily stand somewhat apart.

Almost all ruminants harbor the liver fluke (*Fasciola hepatica*). This worm has been found in every variety of the common ox and zebu (*Bos taurus*, var. *Indicus*), in the sheep, goat, and argali (*Ovis aries*, *Capra hircus*, and *G. argali*), in the antelopes and gazelle (*A. dorcas*), in red-deer, roe, and fallow (*Cervus elaphus*, *C. capreolus*, and *C. dama*), and in the two-humped camel (*Camelus bactrianus*). A closely-allied but much larger species of fluke (*F. gigantea*) infests the giraffe (*Camelopardalis*). All these animals are more or less liable to suffer from the "rot" which is produced by these flukes. Into the history of the affection the space at my command does not permit me to enter, but as regards the development of the common fluke I believe the following conclusions to be tolerably well founded. I had long entertained the opinion that our common *Planorbis* plays the rôle of intermediate bearer, and this view has at length received confirmation.

1. The liver fluke, in its sexually-mature state (*Fasc. hepatica*), gives rise to the disease commonly called *rot;* this affection being also locally termed *coathe* (Dorsetshire, Devon), *iles* (Cornwall), and *bane* (Somersetshire). In France it is known as the *Cachexie aqueuse*, and more popularly as *pourriture*. In

Germany the epidemic disease is called *egelseuche,* and in a more limited sense either *die Fäule* or *die Leberkrankheit.*

2. The *rot* is especially prevalent during the spring of the year, at which time the fluke itself and innumerable multitudes of the free eggs are constantly escaping from the alimentary canal of the bearer. The germs are thus ordinarily transferred to open pasture-grounds along with the fæces of the bearer.

3. As it has been shown by dissections that the liver of a single sheep may harbor several hundred flukes, and as, also, a single adult fluke is capable of throwing off several thousand eggs, it is certain that any rot-affected flock is capable of distributing millions of fluke germs.

4. Such flukes as have escaped the host per anum do not exhibit active powers of locomotion. Their slight contractile movements, however, serve the purpose of concealing them in the grass, and probably aid in the further expulsion of eggs, which pass from the oviduct in single file.

5. After the death of the escaped flukes the further dispersion of the eggs is facilitated by the subsequent decomposition of the parent worm, and also by its disintegration, partly occasioned by the attacks of insects. It has been calculated that the uterus of a full-grown fluke may contain upwards of forty thousand eggs.

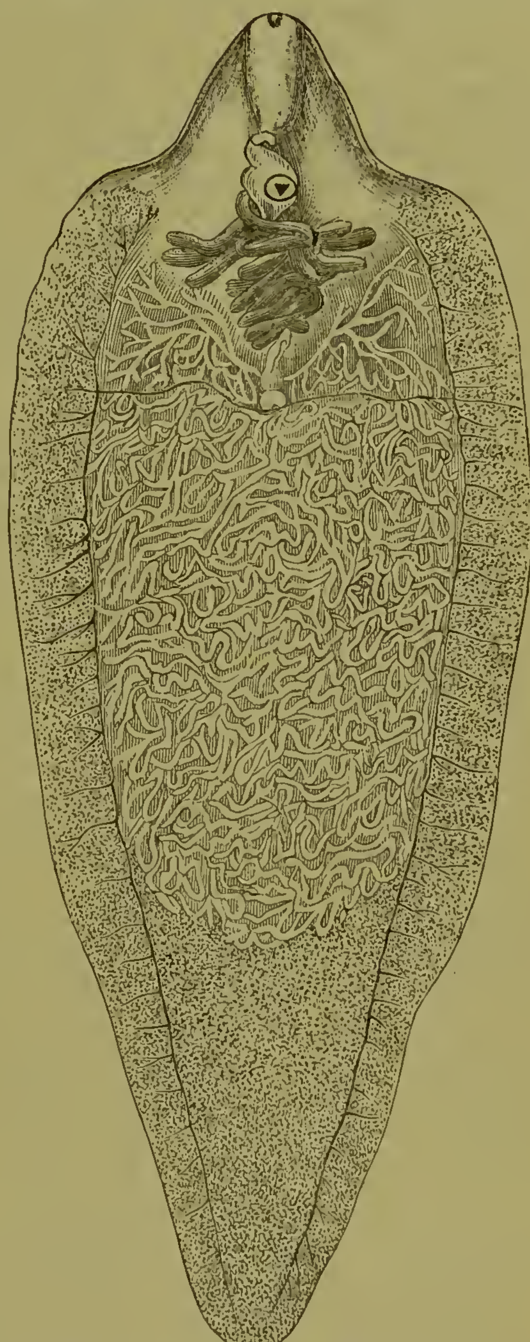

FIG. 61.—*Fasciola hepatica.* Enlarged. After Blanchard.

6. By the agency of winds, rains, insects, the feet of cattle,

dogs, rabbits, and other animals, as well as by man himself, the freed ova are dispersed and carried to considerable distances; and thus it is that a considerable proportion of them ultimately find their way into ponds, ditches, canals, pools of all kinds, lakes, and running streams.

7. At the time of their expulsion the eggs exhibit a finely segmented condition of the yolk. The egg-contents continue to develop whilst outside the parent's body, the granular matrix finally becoming transformed into a ciliated embryo, which when set free follows the habit of infusorial animalcules in general by swimming rapidly in the water. The escape of the embryo is effected at the anterior pole of the egg-shell, which is furnished with a lid that opens in consequence of the action of prolonged immersion, aided by the vigorous movements of the contained embryo.

8. The ciliated, free-swimming embryo, at the time of its birth, exhibits the figure of an inverted cone, its anterior extremity, which is broad and somewhat flattened, supporting a central proboscis-like papilla. A small pigment spot placed dorsally, and having the form of a cross, is supposed to be a rudimentary organ of vision. After the lapse of a few days the cilia fall off, the embryo then assuming the character of creeping larvæ (planulæ).

9. Notwithstanding its abridged locomotive powers the non-ciliated larvæ sooner or later gain access to the body of an intermediary bearer, within or upon whose tissues it becomes transformed into a kind of sac or *sporocyst*. In this condition the larva is capable of developing, agamogenetically, other larvæ in its interior. The sporocysts are highly organised, forming *rediæ*. According to Willemoes-Suhm, the redia of *Fasciola hepatica* lives on the body of *Planorbis marginata*. This organised nurse, which is about a line in length, is the *Cercaria cystophora* of Wagener. The progeny of this redia consists of armed Cercariæ, which after a time quit the nurse to pass an independent existence in the water.

10. In the cases of some species of fluke there is reason to believe that before the *Cercariæ* gain access to their final or definitive host they re-enter the bodies of the mollusks. This they accomplish by means of a boring apparatus, and having previously cast off their tails they encyst themselves beneath the surface of the skin. In this new situation they develop into the so-called *pupa*, which is at length passively transferred

with the fodder, or drink, to the digestive organs of the host. In the case of *Fasc. hepatica*, as probably obtains also with many other flukes, I think there can be no doubt that the Cercariæ pass directly into the bodies of ruminating animals. The circumstance that flukes of this species have been found beneath the human skin shows how considerable are the boring powers of the armed Cercariæ.

In regard to the possibilities of fluke development, that will be best understood by glancing at the constitution of the zoological individual. The sum total of the products of a single germ may be tabulated as follows:—

Zoological individual (*Fasciola hepatica*).

a. Ovum in all stages, *b.* Ciliated free-swimming embryo,	First "biotome."
c. Nurse, germ-sac, sporocyst (*redia*),	Second "biotome."
d. Active, migrating, tailed larva (*cercaria*), *e.* Encysted, resting larva (*pupa*), *f.* Sexually-mature fluke (*fasciola*).	Third "biotome."

This is a fair representation of the life-phases of the fluke. The life-phases are rarely less numerous or complicated than here indicated, but Pagenstecher's researches tend to prove that under certain climatal conditions the number of larval forms may vary considerably. In other words, the fluke individual does not comprise any definite number of "zoöids," although the kinds of zoöids are limited. I recognise three "biotomes." The first includes only one temporary, independent life-phase, this is the ciliated animalcule, which I call a "protozoöid." The second "biotome" may comprise only a solitary simple sporocyst or germ-sac (deuterozoöid), but an almost indefinite multiplication of new and independent germ-sacs, as well as other more highly organised "nurse formations," may also be developed from the primary sporocyst (secondary and tertiary "deuterozoöid"). The third "biotome" embraces a large but variable number of "tritozoöids" (*cercariæ*), an equal number, whatever that may be, of "tetartozoöids" (pupæ), and, therefore, also, a similar number of "pemptozoöids" (flukes).

Practically, other curious results arise out of the foregoing considerations. For example, a single sheep may harbor 1000 flukes. Each fluke will develop 10,000 to 40,000 eggs. Each egg may give rise to 370 zoöids. It thus appears that, if all the conditions were favorable, a single fluke might originate between

three and four millions of individualised life-forms, whilst the solitary sheep itself would, under the same circumstances, be the means of causing the production of at least 3,000,000,000 fluke zoöids! Happily, no such results as this can possibly occur in nature, since interfering agencies reduce the favorable conditions. However, the balance of parasitic forms from all sources is usually sufficient to destroy thousands of sheep annually. The virulence of rot-epizoöty is entirely due to the presence of conditions favoring the development of fluke larvæ.

As regards the injurious action of this parasite on animals, it is well known that in particular years, in England alone, hundreds, and even thousands, of sheep have been destroyed in a single season. A writer in the 'Edinburgh Veterinary Review' for 1861 states that in the season of 1830-31 the estimated deaths of sheep from *rot* was between one and two millions. This would, of course, represent a money loss of something like four million pounds sterling. As affording additional striking instances of the disastrous effects of rot, I may cite the statements of Davaine. Thus:—"In the neighbourhood of Arles alone, during the year 1812, no less than 300,000 sheep perished, and at Nimes and Montpellier 90,000. In the inner departments, during the epidemic of the years 1853-54, many cattle-breeders lost a fourth, a third, and even three fourths of their flocks." In like manner our English authority, Prof. Simonds, furnished a variety of painful cases. Thus, on the estate of Mr Cramp, of the Isle of Thanet, the *rot epidemic* of 1824 "swept away £3000 worth of his sheep in less than three months, compelling him to give up his farm." Scores of cases are on record where our English farmers have individually lost three, four, five, six, seven, and even eight hundred sheep in a single season; and many agriculturists have thus become completely ruined.

Remarkable periodic outbreaks of this disease are recorded by Simonds as occurring in England in the successive years of 1809, '16, '24, '30, '53, and '60; whilst, for France, Davaine mentions 1809, '12, '16, '17, '20, '29, '30, '53, and '54, as the most remarkable years. It would be interesting to know how far these outbreaks tally with the similar outbreaks which have occurred in Holland, Germany, and other European districts. The disease was prevalent during four separate years in France and England at one and the same time. This, indeed, is no more than we would naturally expect, considering that the extent of the

development of the larval forms must, in a great measure, be dependent upon atmospheric conditions. A warm and moist season would alike prove beneficial to the development of the larvæ and their intermediate molluscan hosts. Their numbers would also multiply enormously; for, as already remarked, the degree of non-sexual production of trematode larvæ within their sporocysts is materially affected by climatic changes. On the other hand, a fine, dry, open season will tend to check the growth and wanderings of the larvæ, and thus render the flocks comparatively secure.

Considerations like these sufficiently explain many of the crude theories which were early propagated concerning the causes of this disease, and in particular, the very generally prevalent notion that water, and water alone, was the true source of the disease. Intelligent cattle-breeders and agriculturists have all along observed that the *rot* was particularly virulent after long-continued wet weather, and more especially so when there had been a succession of wet seasons. They have likewise noticed that flocks grazing in low pastures and marshy districts were much more liable to invasion than sheep which pastured on higher and drier grounds, but noteworthy exceptions occurred in the case of flocks feeding in the salt-water marshes of our eastern shores. The latter circumstance appears to have suggested the common practice of mixing salt with the food of sheep and cattle, both as a preventive and curative agent; and there can be little doubt that this remedy has always been attended with more or less satisfactory results. The intelligible explanation of the good effected by this mode of treatment we shall find to be intimately associated with a correct understanding of the genetic relations of the entozoon, for it is certain that the larvæ of *Fasciola hepatica* exist in the bodies of fresh-water snails. As already hinted from Willemoes-Suhm's observations, it is not improbable that the larvæ are confined to gasteropod mollusks belonging to the genus Planorbis.

The symptoms produced by *rot* are very striking. When the disease has far advanced it is easy to know a rotten sheep, not only by its very look, but still more convincingly, as I have myself tested, by slightly pressing the hand over the region of the loins. In this region the diseased animal is particularly weak, and the pressure thus applied instantly causes it to wince. At the same time the hand feels a peculiar sensation very unlike that communicated by the spine of a sound animal. In bad

cases the back becomes hollow, and there is a corresponding pendulous condition of the abdomen. The spinal columns ultimately stick out prominently, forming the so-called "razor-back." As Professor Simonds has well observed, in an earlier stage of the disease, "an examination of the eye will readily assist in determining the nature of the malady. If the lids are everted it will be found that the vessels of the conjunctiva are turgid with pale or yellowish colored blood, the whole part presenting a peculiar moist or watery appearance. Later on, the same vessels become blanched and scarcely recognisable." The skin also becomes harsh and dry, losing its natural tint, and the wool is at length rendered brittle, either becoming very easily detached or falling off spontaneously.

The first thing noticeable in dissecting a rotten sheep is the wasted and watery condition of all the tissues. There is a total absence of that firm, fresh, carneous look which so distinctively characterises the flesh in a state of health. Not only is the rigidity and firm consistency of the muscles altogether wanting, but these structures have lost that deep reddish color which normally exists. When the abdominal cavity is opened a more or less abundant, clear, limpid, or yellowish fluid will make its escape, and the entire visceral contents will, at the same time, display a remarkably blanched aspect. These pathological changes are also shared by the important organ especially affected, namely, the liver. This gland has lost its general plumpness, smoothness, and rich, reddish-brown color, and has become irregularly knotted and uneven both at the surface and the margins, its coloring being either a dirty chocolate brown, more or less strongly pronounced at different parts, or it has a peculiar yellowish tint, which in places is very pale and conspicuous. To the feel it is hard and brawny, and when incised by the scalpel, yields a tough and, in places, a very gritty sensation. On opening the gall-ducts a dark, thick, grumous, biliary secretion oozes slowly out, together with several distomes, which, if not dead, slowly curve upon themselves, and roll up like a slip of heated parchment. On further slitting open the biliary passages, they are found distended irregularly at various points, and in certain situations many flukes are massed together, having caused the ducts to form large sacs, in which the parasites are snugly ensconced. The walls of the ducts are also much thickened in places, and hardened by a deposit of coarse calcareous grains on their inner

surface. Mr Simonds says, that the "coats of the *ductus hepaticus*, as also of the *ductus communis choledicus*, are not unfrequently so thick as to be upwards of ten times their normal substance, and, likewise, so hard as to approach the nature of cartilage." Respecting their numbers, the greatest variation exists. The presence of a few flukes in the liver is totally insufficient to cause death; consequently, when a sheep dies from rot, or is killed at a time when the disease has seriously impoverished the animal, then we are sure to find the organ occupied by many dozen, many score, or even several hundred flukes. Thus from a single liver Bidloo obtained 800, Leuwenhoeck about 900, and Dupuy upwards of 1000 specimens. Even the occurrence of large numbers only destroys the animal by slow degrees, and, possibly, without producing much physical suffering, excepting, perhaps, in the later stages. Associated with the above-described appearances, one also not unfrequently finds a few flukes in the intestinal canal, whilst a still more interesting pathological feature is seen in the fact that the bile contained in the liver ducts is loaded with flukes' eggs. In some cases there cannot be less than tens or even hundreds of thousands. Not a few may also be found in the intestinal canal and in the excrement about to be voided. Occasionally dead specimens become surrounded by inspissated bile, and gritty particles deposited in the liver ducts, thus forming the nuclei of gall-stones. Mr Simonds mentions a remarkable instance, "where the concretion was as large as an ordinary hen's egg, and when broken up was found to contain about a dozen dead flukes. It was lying in a pouch-like cavity of one of the biliary ducts."

In respect of treatment we all know that "prevention is better than cure." Moisture being essential to the growth and development of the fluke-larvæ, it is clear that sheep cannot be infected so long as they remain on high and dry grounds, and even in low pastures they can scarcely take the disease so long as they are folded, and fed on hay, turnips, and fodder procured from drier situations. When once the malady has become fairly developed, internal remedies are of little avail, at least, in view of producing a thorough cure. Palliative treatment may undoubtedly do good, especially in cases where the disease is not very strongly pronounced. The most important thing is the transference of the rot-affected animals to dry ground and good shelter, supplying them, at the same time,

with a liberal quantity of manger food, such as beans, peas, and other leguminous seeds. The fodder, of whatever kind, should be frequently changed, and many other hygienic measures adopted, all tending to promote the appetite and general health of the animal. An admixture of salines is a matter of essential importance, especially in cases where the disease is not far advanced. The beneficial effect of salt is one of those few points on which nearly all parties are agreed, and its preservative influence in the case of sheep fed upon salt-water marshland has been previously explained. In regard, however, to the legion of remedies which have from time to time been proposed, all I need here say is, that most of them when fairly tested have been found to fail ignominiously. Every year we hear of the adoption, often with enthusiasm, of new so-called specifics, or of ancient medicines whose employment had long fallen into disuse. Thus, for example, in the April number of the 'Journal des Vétérinaires du Midi' for 1860, we find M. Raynaud strongly recommending soot, in doses of from one to three spoonfuls, to be followed up by the administration of a grain of lupin for tonic purposes. In like manner, we received from France wonderful accounts of the medicinal virtues of a certain fœtid oleaginous compound, the value of which was put to a fair test by our distinguished veterinarian, Professor Simonds. Having with infinite care and trouble undertaken a series of experiments with the remedy in question, Mr Simonds writes in the 'Scottish Farmer and Horticulturist' to the effect that, as a result of his inquiries, he fears "we must conclude that this supposed cure of *rot* in sheep has proved quite ineffective for good." The last new "cure" announced is by Mr Robert Fletcher ('Journ. Nat. Agric. Soc. of Victoria,' Dec., 1878).

The examination of rotten sheep is not altogether free from danger. Professor Simonds tells us that in August, 1854, "a person of intemperate habits, following the occupation of a country butcher, was employed in skinning and dressing a number of rotten sheep on the premises of a farmer in the county of Norfolk. The sheep were necessarily opened when *warm*, and while he was so engaged he complained greatly of the sickening smell. The same evening he was attacked with choleraic disease, and two days afterwards was a corpse." This case is highly instructive and, when taken in connection with the well-known fact that animals affected with the disease putrefy very rapidly, clearly points to the neces-

sity of removing slaughter-houses far away from densely populated localities.

Notwithstanding the above statement, there is little or no danger to be apprehended from the consumption of the flesh of rot-affected animals. On this vexed question we have the strong testimony of the late Dr Rowe, of Australia, who, after leaving the medical profession, became a large and successful stockowner, and devoted himself especially to this question. Dr Rowe, writing from the Goulburn district, said :—The mere presence of flukes in the viscera of an animal is no proof that it is unfit for human food. For inspectors of slaughter-houses to adopt such a test of wholesome food would be the greatest mistake. It would afford no protection to the public against unhealthy food, would increase the price of animals, and be ruinous to our farmers and graziers. If the consumption of flukey beef and mutton were prejudicial to the health of man, there would be very few people alive in this part of the colony; for, to my certain knowledge, they have had no other animal food to live upon for the last twenty-five years, yet for physical ability I believe they may be favorably compared with the inhabitants of any other part of Australia." Speaking of his own experiences, Dr Rowe avers that he found the common liver fluke in sheep, cattle, goats, opossums, kangaroos, geese, ducks, and other creatures, but he had never encountered it in men, dogs, or pigs. On the whole I think we may agree with Dr Rowe, in regarding the consumption of the flesh of rot-affected animals as free from danger provided only the meat, be well or even moderately well cooked. It must be borne in mind, however, that an essential objection to its consumption lies in the fact that the watery and otherwise chemically deteriorated flesh is comparatively innutritious. It must also be noted that the meat-supply from fluke-affected animals, as usually sold in the markets, is chiefly derived from animals which have only entered the early stage of the disorder, that is, long before the watery and wasted condition of the muscles has fairly set in.

Respecting the other trematodes I have to observe that *Distoma lanceolatum* not only infests the liver ducts of cattle and sheep, but also the deer tribe. Its larvæ are likewise supposed to reside in *Planorbis marginatus*. Still more common and widespread amongst ruminants is the *Amphistoma conicum*, occupying the paunch. It has been found in the ox, sheep,

musk-ox, elk, roe, fallow, red-deer, goat, and dorcas-antelope; also in *Cervus campestris*, *C. nambi*, *C. rufus*, and *C. simplicornis*. Prof. Garrod has also recently shown me examples from the sambu deer of India (*C. Aristotelis*). Diesing's *A. lunatum*, infesting *Cervus dichotomus*, is inadmissible. Two other species of Amphistome (*A. explanatum*, *A. crumeniferum*) are said to infest the zebu; and I have described another (*A. tuberculatum*) from the intestines of Indian cattle. An aberrant amphistomatoid entozoon (*Gyrocotyle rugosa*) has been found in a Cape antelope (*A. pygarga*). Of more interest, however, is the circumstance that Dr Sonsino has discovered a species of Bilharzia (*B. bovis*) in Egyptian cattle and in sheep. The eggs of this species are distinctive, being fusiform and narrowed towards either pole.

Comparatively few tapeworms are found in ruminants. Cattle are infested by *Tænia expansa* and *T. denticulata*, the former of these two species being also more or less prevalent in sheep, antelopes, and deer. Other alleged species (*Tænia fimbriata* and *T. capræ*) appear to me more than doubtful. Unquestionably the common *Tænia expansa* is capable of giving rise to severe epizoöty among lambs. The privately communicated evidence of Professors Brown and Axe, and published evidence supplied by Messrs Cox and Robertson on this head, are conclusive. Mr George Rugg has also (in a letter to Prof. Simonds, dated Dec. 4th, 1878) communicated the particulars of an outbreak in which "large numbers of lambs perished rapidly" from tapeworms in the intestines, the parasites varying from one to five or six feet in length. This tapeworm (*T. expansa*) is also very prevalent in Germany. Ruminants, however, both at home and abroad, suffer much more severely from bladder-worms. Of these, *Echinococcus veterinorum*, *Cysticercus tenuicollis*, and *Cœnurus cerebralis*, are not only shared alike by all varieties of cattle, sheep, and goats, but they also infest the deer tribe, antelopes, the giraffe, and even camels. In 1859 I obtained the slender-necked hydatid from a spring-bok (Gazella). Besides these larval cestodes, cattle are very liable to harbor measles (*Cysticercus bovis*), whilst sheep also entertain an armed Cysticercus (*C. ovis*). I cannot again dwell at any length upon the source of these immature helminths, but I may remark upon the extreme frequency of measles in Indian cattle. This is explained by the careless habits of the people. They not only consume veal and beef in an imperfectly cooked state, but when

suffering from tapeworm no precautions are taken to prevent cattle from having access to the expelled proglottides of *Tænia mediocanellata.* The subject has already been dealt with in the first part of this work, and also in my 'Manual,' quoted in the bibliography. The mutton measle is described under the heading of *Tænia tenella.* In like manner I must refer to the 'Manual' for a detailed account of the gid hydatid (*Cœnurus cerebralis*). How many kinds of Cœnuri exist it is impossible to say, but I am of opinion that the various polycephalous bladder-worms found by Rose, Baillet, and Alston in rabbits, by myself in a lemur and in a squirrel, and by Engelmeyer in the liver of a cat, are referable to tapeworms specifically distinct from the *Tænia cœnurus* of the dog.

It was in 1833 that Mr C. B. Rose, formerly of Swaffham, Norfolk, discovered an undoubted example of polycephalous hydatid in the rabbit, the parasite in question bearing a very close resemblance to *Cœnurus cerebralis.* As the accuracy of Rose's determination respecting the characters of the hydatid has been called in question, I again invite attention to the original description as recorded in the 'London Medical Gazette' for November 9th, 1833. At page 206, vol. xiii, of that periodical, after describing the common *Cœnurus cerebralis* of the sheep, Rose writes :—" This (*i.e. C. cerebralis*) is the only species of Cœnurus noticed by authors, but I have met with another. It infests the rabbit, and I have found it situated between the muscles of the loins. It is also met with in the neck and back. This hydatid grows rapidly, and multiplies prodigiously, and being seated near the surface it soon projects, and sometimes forms a tumour of considerable magnitude. When the warrener meets with a rabbit thus affected, he punctures the tumour, squeezes out the fluid, and sends the animal to market with its brethren. I possess a specimen of this species in a pregnant state. The earliest visible state of gestation is a minute spot, more transparent than the surrounding coats of the parent; this enlarges till it projects from the parietes of the maternal vesicle. It continues to enlarge until it becomes a perfect hydatid, attached by a slender peduncle only; even whilst small, other young are seen sprouting from it, and so on in a series of three or four. My specimen exhibits them in every stage of growth, from a minute point to a vesicle the size of a hen's egg. As I can see no difference in structure between this hydatid and the last-mentioned (*i.e. Cœnurus cerebralis*), I am unwilling to consider it a different

species, for surely a varying locality ought not to constitute a specific character."

The observations of Rose did not escape the well-known Dutch author, Numan. In a foot-note to his memoir, entitled "Over den veelkop-blaasworm der Hersenen," he makes the following observations :—"Rose observes that he has found Cœnurus in bladdery rabbits (blaaszieke konijnen) in the skin, and in the cellular tissues of the trunk and extremities. The veterinary surgeon, Engelmeyer, of Burgau, says he has also found the *Cœnurus* (Veelkop) in the liver of a cat ('Thierärztliche Wochenschrift van 1850,' s. 192). These observations differ thus far from those of other writers, according to whom the Cœnurus is only found in the brain and spinal marrow. However, it is not impossible in particular cases that some parasites may have strayed from their ordinary dwelling-places." Numan seems to have been not a little puzzled to account for these discrepancies, and he was altogether undecided regarding the mode of propagation of Cœnuri and Cysticerci. This will be gathered from the following passage, which I quote in the original :

"Ik moet het onbeslist laten, of de grondbeginsels, waaruit de wormen uit de blaas ontspruiten, als wezenlijke of als zoogenaamde kiemen (*gemmæ*) zijn te houden, waaromtrent de gevoelens der voornamste Natuuronderzoekers, die zich met de nasporing der blaaswormen hebben onledig gehouden, nog uiteenloopen. Gulliver, door Rose (a. p. pag. 231) aangehaald, houdt ze voor eijeren, in den *Cysticercus tenuicollis,* en Goodsir, mede aldaar genoemd, spreekt ook van *ova* bij den *Cœnurus cerebralis;* doch de laatstgenoemde en Busk houden ze voor *gemmæ.* Hier wordt voots gewezen op Owen en de meeste onderzoekers van den tegenwoordigen tijd, die het daarvoor houden, dat alle hydatiden zich alleen door *gemmæ* reproduceren. Rose merkt voorts aan, dat, hetzij men de geboorte dezer ingewandswormen toekenne aan eijeren of kiemen (*gemmæ*), dit om het even is, wat hunne verspreiding (*dissemination*) betreft, daar zij ingesloten zijn, waardoor de wijze, hoe zij naar buiten komen en verspried worden, tot dusver een gesloten boek is."

The idea of Numan that these are strayed forms of *Cœnurus cerebralis* is not convincing. It must not be forgotten, however, as Leuckart and Numan have both reminded us, that Eichler discovered an hydatid about the size of a goose egg in the subcutaneous tissue of a sheep. This bladder-worm supported

nearly two thousand heads. In regard to true hydatids or acephalocysts in ruminants, on which subject I have already dwelt at much length, I may again observe that the Hunterian Museum contains some remarkable examples. In 1854 I obtained Cysticerci from a giraffe, and I have reason to believe that similar bladder-worms infest antelopes and deer.

The nematodes of the ruminants are both numerous in, and destructive to, their bearers, those infesting the lungs being productive of a parasitic bronchitis termed husk or hoose. In cattle the lung-worm (*Strongylus micrurus*) is particularly fatal to calves, whilst *S. filaria* attacks sheep, and especially lambs. A larger but less common lung strongyle (*S. rufescens*) is sometimes found associated with the latter. In 1875 I conducted experiments with the view of finding the intermediate hosts of *S. micrurus*, and I arrived at the conclusion that the larvæ of this parasite are passively transferred to the digestive organs of earth-worms. The growth and metamorphoses which I witnessed in strongyloid larvæ taken from earth-worms (into which I had previously introduced embryos) were remarkably rapid, and accompanied by ecdysis. The facts were as follows. About the middle of October, 1875, I received from Messrs Farrow, of Durham, a fresh and characteristic specimen of diseased lungs, in which the bronchi were swarming with Filariæ.

In reference to the case itself, Mr George Farrow afterwards informed me by letter that the calf was one of a herd of seven, whose ages respectively varied from four to six months. At the time of his writing (October 20th) the remaining six animals were progressing favorably towards recovery—a result which Mr Farrow attributes to the employment of inhalations of turpentine and savin, combined with the internal adminstration of tonics. In regard to this plan of treatment, and in reference to the source of infection, he adds :—" I should have preferred trying the inhalations of chlorine gas, but as the patients were so very young and in poor condition, I deemed it advisable to try a milder course of treatment.

" The history of the case is brief. The cattle are on a very dry and well-drained farm, but during the summer there was a great scarcity of water, and they were supplied from a stagnant pool which eventually became dry. This, in my opinion, is where the disease originated."

Mr George Farrow's opinion is probably correct, being in harmony with the most recent results of scientific research as

made known more particularly by Leuckart. But the facts thus conveyed do not explain the whole truth; or, rather, they convey it only in a very incomplete manner. Professor Leuckart's experiments were made with several species such as *Strongylus armatus* of the horse, *S. rufescens*, *S. hypostomus*, and *S. filaria* of the sheep, and *S. commutatus* of the hare. Still, as regards the strongyles, partial as the results have thus far appeared, there cannot be a doubt that his successes with several allied nematode species form a key by which we may yet unlock and expose to view the entire life-history of that specially obnoxious form under consideration, namely, *Strongylus micrurus*. To summarise the whole matter in a few words, Leuckart supposes that all these strongyloids require a change of hosts before they can take up their final abode in the sexually-mature state. This he infers especially because their respective embryos display characters very similar to those exhibited by *Olulanus*. He believes that either small mollusks or insects and their larvæ play the *rôle* of intermediary bearer. His experiments with the embryos of *Strongylus filaria* prove that these larvæ can be kept alive for several weeks in moist earth, and that whilst so conditioned they undergo a first change of skin within a period varying from eight to fourteen days. Experiments on sheep, made with these moulting larvæ, led only to negative results. Unless the following facts be accepted, the scientific position remains pretty much where Leuckart left it.

On the 22nd of October, 1875, at 1 p.m., I placed the entire egg-contents of the uterus of a *Strongylus micrurus* on a glass slide hollowed out in the centre. Probably something like ten thousand ova were thus brought under observation, yet only three were noticed as freed from their shells, probably as the result of accidental rupture. Two of these displayed lively movements. In round numbers the ova gave a measurement of $\frac{1}{300}$ of an inch in length by $\frac{1}{750}$ of an inch in breadth, whilst the free embryos measured about $\frac{1}{90}$ of an inch long, and less than $\frac{1}{1000}$ of an inch in thickness. The integument of the embryo displayed neither markings of any kind nor any double contour. The contents of the worm were granular throughout, these granules being crowded in the centre of the body, but scarcely visible towards the head and tail, where for a considerable space (fully $\frac{1}{300}''$) the worm was perfectly transparent. No trace of any sexual organs or their outlets was visible. An examination of numerous eggs and free embryos obtained from near the

primary bronchial bifurcations (of Mr Farrow's specimen) yielded the same microscopic results, the only thing worthy of remark being that the embryos from the mucus seemed much more lively than those which, as I supposed, had accidentally escaped their shells.

At 1.30 p.m. I placed some free embryos in two watch-glasses, one containing water and the other saliva, and placed them before the fire. Being called away professionally I found on my return at 3 p.m. that evaporation to dryness had occurred in the interval. All my attempts to resuscitate the embryos by moisture proved unavailing, a result which, though negative, proves how little capable these embryonic creatures are of enduring desiccation. If these facts be confirmed, their practical significance is not without value in relation to the choice of dry pasturage grounds for the rearing of young cattle. I may add that whilst half an hour's immersion of the dried embryos failed to restore any sign of life, the previous warmth and moisture had caused many more embryos to escape their shells during the time they were placed before the fire.

At 4 p.m. I passed some very rich mould through muslin. Some of this finely sifted earth I placed in a watch-glass, adding a little water to moisten it, and also numerous eggs and free embryos. In a wine-glass and also in a small jar I placed some coarse earth with water added to make thin mud, and to both of these I added, not only eggs and embryos, but also portions of the reproductive organs of the adult female worms.

On the 23rd of October, at 2 p.m., I examined the contents of these vessels. All the embryos in the vessels containing the coarse earth were dead, but several were found alive in the watch-glass containing the fine moist mould. Structually these latter had undergone no perceptible change beyond a somewhat closer aggregation of the somatic granules.

Although the embryos in the coarse wet mud had perished, the eggs with unhatched embryos appeared to have retained their vitality. Of this fact, indeed, I subsequently obtained abundant proof; and I also satisfied myself that the death of the embryos had not resulted either from the coarseness of the earth or from excessive moisture, but from the presence of numerous shreds of the uterine tubes which I had somewhat carelessly added to the vessels. Previous experiments, conducted many years back, had indeed taught me that few if any

nematoid larvæ can resist the fatal action of putrid matter, however slight the putrescence.

Having removed the offending shreds, I next placed a quantity of living ova together in the earthenware jar, and allowed the earth-contents to become much drier by evaporation before the fire. I also left others in a watch-glass, which was placed under a bell-jar enclosing several ferns.

On the 25th of October I removed particles of the moist earth, altogether weighing about two grains, and, on submitting them to microscopic examination, had the satisfaction to observe about a dozen living embryos, some of which exhibited very lively movements. There was not the slightest indication of putridity; nevertheless, I noticed several shreds of the adult worms whose presence had been accidentally overlooked, and, curiously enough, all the embryos subsequently removed from the immediate neighbourhood of these decomposing shreds of tissue were almost motionless and apparently in a moribund condition. On examining the contents of the watch-glass placed under the fern shade, I noticed several points of interest. First of all the earth contained strongyle embryos, such as I had seen before. Secondly, the surface of the mould was being traversed by three or four briskly-moving *Thysanuridæ*, hunting about with all that restless activity which Sir John Lubbock has so well described. Thirdly, in marked contrast to the behaviour of these I noticed several slow-moving *Acaridæ*, apparently also employed in searching for food. And lastly, while thus engaged, the surface of the mould in the centre of the deep watch-glass was suddenly upheaved, by which I was at once made aware of the presence of another most welcome and unexpected intruder. In short, an earth-worm had crept from the dry mould in which the ferns were growing, and had taken up its temporary abode in the soft moist experimental-earth contained in the watch-glass. When contracted, this *Lumbricus terrestris* was barely an inch in length. On placing it under the half-inch objective glass, I noticed a single embryonic strongyle adhering to the skin, but not firmly, and evidently only in an accidental way, so to speak. It was clear to me that it possessed neither the intention nor the power to penetrate the chitinous integument of the earth-worm.

Having in the next place removed the *Lumbricus* with a pair of forceps, and having washed it under a current of water, I snipped off the lower end of the body, and allowed some of the intestinal contents to escape on a clean glass slide for separate

microscopic examination. Immediately, to my satisfaction, I found that the fæcal contents displayed a large quantity of my strongyle ova, enclosing still living embryos, and in addition several free embryos presenting characters which declared that they were from the same source. Clearly they had been ingested by the earth-worm along with its ordinary food. One or two of the embryos were conspicuously larger than their fellows, but the structural changes they had undergone were not so marked as to lead me for a single moment to associate them with any of the various sexually-mature worms which have been described as normally infesting the earth-worm. I had no doubt whatever that such slight structural changes as were now discernible had resulted from growth and development consequent upon this accidental admission into the body of the intermediate bearer which might or might not prove to be its legitimate territory. It will be seen that subsequent observations tended to affirm the truth of this view. I made a careful examination of one of these larvæ, whose active movements were such as to render the process exceedingly tedious. The earth-worm itself (or rather its unequal halves) was placed in a fresh watch-glass containing ordinary mould. The larvæ or embryos obtained from the earth-worm now measured about $\frac{1}{80}$ of an inch in length, their heads exhibiting a short and simple chitinous buccal tube, whilst their tails were somewhat more pointed and bent upward. The somatic granules were more crowded, rendering the position of the intestinal tract more marked, though, as yet, the differentiation gave no indication of the formation of a distinct intestinal wall. There was no perceptible increase of thickness of the body of the embryos. The results thus far naturally encouraged me to procure some fresh earth-worms for experimental purposes.

On the 26th of October I found that the halves of the earth-worm were alive, and I left them undisturbed in rather dry mould, freshly added. To a watch-glass containing newly sifted earth and embryos I added a fresh garden-worm, which was rather sluggish from the cold; and in the original jar I placed another smaller and very active earth-worm obtained the same morning. Finding the soil in the jar congenial, this *lumbricus* soon buried itself. Another and larger earth-worm subsequently added refused to follow this example. It was therefore removed from the jar. Believing the fine and arti-

ficially prepared soil to be still much too moist, I caused further evaporation; and I afterwards found that the thicker the mud the more suitable it proved as a residence for embryonic nematodes and earth-worms alike.

On the 27th I found the small earth-worms in the jar burrowing freely and throwing up fæcal casts. From one of my watch-glasses the worm had escaped, its place being occupied in the meantime by an actively crawling *Julus*. I put a second *Julus*, obtained from the mould in the fern jar, to form a companion (in view of other experiments), and I also added a fresh earth-worm, covering all by another inverted watch-glass, which I thought would prevent their escape.

In the next place I examined the halves of my original experimental earth-worm. They were scarcely capable of motion, but retained a certain amount of vitality. The tail was the more active half, and unfortunately it was soon afterwards lost. Carefully washing the superior half, and transferring its contents to a glass slide, I immediately detected under the microscope a large number of embryos. They were in a state of marked activity, the largest having increased to about $\frac{1}{50}''$ of an inch in length, whilst their structure had become correspondingly advanced. Here, again, there was no room for doubt as to their source, especially as they individually displayed different degrees of organisation, all answering to one and the same embryonal type. I now observed a distinct œsophagus, the rest of the intestinal tract being still more conspicuous than heretofore, though, as yet, no true cells marked the limitation of the stomach and chylous intestine.

After an hour's immersion in cold water some of the larvæ became much less active, whilst others were motionless, so that I feared all were about to perish. In the hope of keeping a few of them alive I now added to the slide some finely sifted grains of mould, placing the slide under a small bell jar which protected some of my ferns. The remains of the moribund earth-worm were also covered with mould.

Other larvæ, derived from the earth-worm, were placed on the moist pinnæ of a living fern-frond which supported small drops of water, for by this process I hoped in some measure to imitate the dew which naturally condenses on the grass and fodder of our low-lying fields. At 3.15 p.m. of the same day (27th) I also examined a fresh worm pellet from the jar, and found it to contain living strongyle embryos, which as

heretofore had not exhibited the slightest advance either in respect of size or structure.

At noon on the 28th I again sought for the larger larvæ, first of all on the slide covered with fine earth, and afterwards within the remains of the upper half of the original earth-worm. On the slide I could detect none, but within the intestine of the worm there were still two living larvæ left, whose characters corresponded precisely with the largest that I had previously obtained from the same source only the day before. They had undergone, however, no further change in structure, and their measurements remained precisely the same.

At 12.30 p.m. I snipped off two or three of the terminal fern-fronds on which I had placed a few advanced larvæ. On examination under the half-inch objective I immediately detected one of the larvæ cruising about most actively. On adding a drop of water it soon rushed across the field of the microscope, its movements being thoroughly eel-like. The size of this larva had so much increased that it was now visible to the naked eye, measuring, indeed, as much as $\frac{1}{30}''$ of an inch from head to tail. Moreover, its organisation had advanced in a marked degree. Thus, the digestive organs were better defined, and on one side of them there appeared a regularly arranged congeries of cellules, forming the commencement of the reproductive organs. As yet, however, I could not pronounce as to the sex.

At 1.45 p.m. I again examined a few grains of earth from the jar, when I at once noticed five or six active embryos whose structure failed to show the slightest advance upon that originally described. It was evident that the jar contained thousands of them; and since no ova were found, it became probable that all their embryonic contents had escaped to swell the number of free larvæ, leaving their very delicate envelopes to perish. I think I had hit upon the most suitable degree of moisture favorable to this result.

In the next place I sought for the earth-worm that had been placed in the infested soil between two watch-glasses. It had escaped. This obliged me to transfer the mould to a rather wide-mouthed and open phial, in which four more fresh lumbrici were placed. I feared the closing of the bottle would be detrimental.

Later in the day I selected an earth-worm which had not been exposed to strongyle infection, but which was in a mori-

bund condition. In the intestine there were several free nematoids and also several psorosperms of the genus *Monocystis*, so well illustrated by E. Ray Lankester. As to the nematoids, which were filariform, they neither corresponded in size nor structure with my strongyle embryos.

At 1 p.m. on the 29th I renewed my examination of the larva removed from the fern-pinnule. It showed a further stage of growth, the male character of the reproductive organs having become apparent. The now tolerably well-formed vas deferens had pushed the chylous intestine on one side, whilst a series of caudal rays, five on either side, supported two narrow membranous wings, which represented the lateral lobes of the hood of the adult strongyle.

At 1.30 p.m. I submitted the intestinal contents of four fresh earth-worms removed from my garden to microscopic examination, but no nematoids were found in any one of them.

About 2 p.m. I removed another large and active strongyle larva that had been reared on another fern-pinnule. It was of the same size as that previously described, but was in the act of changing its skin. It was then put aside along with the other worm under the glass shade.

At 3 p.m. I intended to have examined one or more of the earth-worms placed in the open-mouthed phial, but all had escaped and buried themselves in the fern-mould out of reach.

At noon on the 30th I renewed my examination of the two large larvæ whose developmental changes I had been instrumental in producing from the time of their escape from the egg-coverings. I saw no reason to doubt that the sequence of changes thus far noticed referred to the species of parasite under consideration. Both larvæ were active, but the moulting one had now completed its ecdysis. Its sexual distinctiveness had become yet more pronounced by the formation of two rather short and stout spicules, the point of the tail displaying a very minute awl-shaped projection. The lateral membranes had not visibly increased in size. One of these larvæ, the first under observation, now perished from the injuries sustained during inspection.

Again, and later in the day, I sought to clear up any doubts that might still suggest themselves respecting the source of these larvæ, by once more submitting the intestinal contents of two fresh and uninfected earth-worms to careful scrutiny. In the first worm no parasite could be found, and in the second

only one minute nematoid; its organisation, which was sexually incomplete, neither corresponded with my strongyle embryos, nor, so far as I could judge, with Goeze's *Ascaris minutissima microscopica* (the *Anguillula lumbrici* of Diesing and others), nor with Dujardin's *Dicelis filaria.* It was a very long and narrow creature, but I lost it whilst attempting to secure an accurate measurement. I should say it was about $\frac{1}{50}$th of an inch in length, and not more than $\frac{1}{1500}$th in breadth. I made a rough outline sketch of it.

In view of further observations I now placed five more earth-worms in the jar containing strongyle embryos, and I also placed six others in the phial which contained coarser mould, and only a comparatively small number of the original strongyle embryos. The phial was closed with a cork and half buried in the fern-mould of one of my larger Wardian fern-pans. Before this transfer was made I again took an opportunity of ascertaining by microscopic evidence that the embryos lodged in the coarse and fine mould had none of them made the slightest advance in organisation. The worms placed in the jar immediately proceeded to bury themselves.

At noon on the 1st of November I sought to get further results from the only large free larva which now remained to me (for the fern-pinnules on which the larvæ were originally placed had dried up and no third specimen could be discovered). Structurally the larva presented no advance. It therefore appeared to me necessary to place it under new conditions in view of exciting further progress towards sexual maturity and adult growth. To transfer it to the bronchus of a living calf would, of course, have been the crucial experiment, but the hopelessness of getting any satisfactory result from this solitary transfer deterred me from the attempt. On a larger scale, with many larvæ, a positive issue would of course prove decisive. Accordingly, the only thing I could do, in partial imitation of nature, was to try and induce some further changes by placing the larva in human saliva, kept warm artificially. As a first step I immersed the creature in a little of the secretion added to the glass slide, when it immediately displayed very lively movements, such as could only be fitly described as frantic. This encouraged me to replace the slide under one of the fern shades without applying any additional heat. I then left it.

At 12.30 p.m. I selected three of the eleven worms lodged in

the infested earth, namely, two from the jar and one from the closed phial, and made a microscopic examination of their respective intestinal contents. In one of the worms from the jar I found several embryos clearly referable to my strongyles, their structure showing scarcely any advance upon that exhibited by the embryos in the mould itself. The weather was now excessively cold and the larvæ were motionless; nevertheless, the application of warmth showed that they were by no means dead. The fæcal matter obtained from the worm that had lived in the phial displayed an immense number of infusoriæ (*Bacteria*) which rushed about rapidly over the field of the microscope. No other signs of life were detected.

On the 2nd of November I found my solitary strongyle larva alive, but its movements, though active, were by no means so active as on the previous day. No fresh structural changes had occurred.

At noon on the 3rd the larva at first lay almost motionless in the now thick and ropy saliva; nevertheless, on applying a thin glass cover its movements became tolerably vigorous. During its quiescent state I succeeded in getting a good view of the caudal rays and other imperfectly developed organs, of which I retain figures.

Having now satisfied myself that other new conditions were necessary to enable the larva to arrive at sexual maturity, I sought to transfer it to a glass tube filled with fresh saliva. This transfer was a matter of difficulty. After passing the thick ropy saliva into the tube, I examined the slide and found that the larva was gone. I concluded it was in the tube, which, in order to keep the contents warm, I subsequently carried about concealed in my under-clothing during the day and placed in my bed during the night. This increase of temperature, however, caused decomposition of the saliva; so when next day I diligently sought for my experimental nematode it was nowhere to be found. Thus terminated my observations on the first set of embryos, which had enjoyed their temporary sojourn in the intestinal tract of the earth-worm, and which had certainly afterwards undergone a series of marked structural and morphological changes, accompanied with ecdysis.

The weather had now been for several days exceedingly cold, but on the 4th a favorable change set in, which led me to hope that I might be able to verify the facts above recorded. Accordingly, as a new point of departure, I re-examined the

fine mould, and at once found my embryos in a high state of activity. The mould, however, appearing too moist for the earth-worms, I permitted further evaporation before closing the jar with a glass cover. Four days subsequently I examined the intestinal contents of two of the earth-worms. In one of these, an inch in length, no parasite of any kind could be detected; but in the other, which was beyond three inches in length, there were numerous *Opalinæ* besides several strongyle embryos, the latter presenting characters not visibly in advance of those still living in the mould. All of them were motionless, as if they had not got over the shock produced by previous cold. Moreover, the weather had again become cold, and thus, when I again inspected my experimental embryos living in the jar, I also found them motionless, so different from their behaviour on the 4th. However, since a further result with the earth-worm embryos appeared possible, I placed some of the fæcal matter, already ascertained to contain a few of them, on the fronds of a thoroughly moist and dew-covered *Asplenium bulbiferum*. This plant was in a fern-pan which had the advantage of considerable fire-warmth during the day. When, however, on the 15th of November, I examined the fæcal earth removed from several of the pinnules, I failed to find any of the embryos. Possibly they had wandered, for the entire frond was covered with dew-drops, which was not the case with the fern that I had previously experimented on with such satisfactory results. At all events, whether they had wandered or had perished, their apparent absence in no way affects my previous record; and the more so since only a few had been observed in the fæcal matter. The smallness of the number found in the earth-worm was also readily accounted for. Thus, when at 1.30 p.m. on the 15th I made a diligent search for embryos in several grains of the fine mould, not a single young strongyle could be detected. Possibly the frost of the previous night had killed them. The earth-worms were still alive and in good condition.

In conclusion, I may observe that every experimenter with helminths is well aware how unfavorable the winter season is for this kind of research. If a repetition of this inquiry in the spring or summer should confirm these results, it will prove a clear and substantial addition to our knowledge of the development of the strongyles. Meanwhile, I think that the data above given render it highly probable that the larvæ of the hoose-producing strongyle (*S. micrurus*) are passively trans-

ferred to the bodies of setigerous annelids, which are thus called upon to act as intermediate hosts. If this be so, it is further certain that important structural changes with ecdysis follow after their escape from the earth-worms or other annelids, moisture, dew, or water being essential to the penultimate stage of growth. Final passive transference, either with fresh fodder from swampy grounds, or, it may be, from pond water, ultimately enables them to acquire their definite sexual form, size, and other adult characteristics.

According to Mégnin it is not the *Strongylus filaria*, but a hitherto unknown and totally distinct species (*Strongylus minutissimus*) which occasions pneumonia in Algerian sheep. In England the parasitic bronchitis affecting sheep is generally called the "lamb disease." This is unfortunate, because many other parasites prove destructive to lambs. One of the most injurious species is *Strongylus contortus*, infesting the true stomach, whilst *S. hypostomus*, occupying the small intestines, is almost equally obnoxious to the ovine bearer. By Leuckart and others this last-named worm is retained in Dujardin's genus *Dochmius*, in which genus another species occurs (*D. cernuus*). This worm is quite distinct, but not readily distinguishable by the naked eye alone. It occasionally occupies the upper part of the colon, as well as the lower end of the small intestine. A rarer intestinal worm in lambs is the *Strongylus filicollis*. Several other strongyles infest the ox (*S. radiatus*, *S. inflatus*, *S. gigas*), goat (*S. venulosus*), and stag (*S. ventricosus*).

As showing the extraordinary prevalence and destructiveness of entozoa in certain countries, I will adduce an instance in which my opinion was requested and given some five years since. My informant stated the case somewhat in the following manner :—On a farm in New South Wales, and lying about 200 miles to the north-west of Sydney, on the Trafalgar tributary of the Macquarie river, out of a flock of about 8000 sheep no less than 1200 have perished. In many instances post-mortem examinations were made, *worms* appearing in all cases to be the cause of death. There were four kinds of parasites present. The most numerous were red and white, "marked like a barber's pole." These occurred chiefly in the fourth stomach and commencement of the duodenum, but some were found throughout the entire length of the small intestine. A second set comprised small black worms, resembling needles, scattered only in the lumen of the intestines. The third set were tapeworms,

each being several fathoms in length. The fourth set was made up of white threadworms, individually measuring two inches in length. These occupied the bronchial tubes, and where characterised by my informant as "the most deadly of all." Without the aid of specimens I at once recognised these brief diagnostic characters as severally referring to *Strongylus contortus*, *Dochmius hypostomus*, *Tænia expansa*, and *Strongylus filaria*.

What the inquirer desired at my hands was "full information respecting the general principles to be carried out in view of the prevention of this parasitic disease, regard being had to the difficulty of finding any food but pasture, to the number of animals to be treated, and to the not unfavorable circumstance that the run is divided by fencing to a great extent." I was also requested to explain the best modes of treatment, being at the same time informed that turpentine drenchings had already been employed with only "partially effective" results. I was also expected to give numerous and varied formulæ, to be tried in succession, supposing the first should fail. Of course, it should have been known that I neither prescribe medicines nor accept fees in respect of animal patients; but, as in this instance my opinion was permitted to assume the form of a "written scientific report," I was pleased to have an opportunity of commenting freely and fully on the significance of the facts submitted. My advice took the form of a long report, which might here be usefully given *in extenso* were it not somewhat of the nature of a private and privileged communication. I have no doubt that the stockowner would be pleased that I should utilise his remarkable "case" for the benefit of agriculturists and others; but it is for him to publish the "opinion" as it stands, should he think fit to do so.

Practical men, on reading the few foregoing particulars, will perceive that one of the principal obstacles to success in cases of this kind lies in the circumstance that artificial food can only be procured with difficulty. Where the source of the disease is associated with the pasture-supply, any treatment, however effectual for a time, can only be followed by partially satisfactory results.

The destructive powers of any one of the above-mentioned parasites being sufficient to produce a fatal lamb-disease, it is clear that when two or more of these particular species attack their victim in considerable numbers, the ovine-bearer has little chance of recovery. The intestinal strongyles, by means

of their oral armature, behaving as veritable leeches, will, if not expelled in good time, produce a rapidly fatal anæmia, precisely in the same way as the human *Anchylostomum* of the tropics.

The worst of dealing with this sheep-parasite is that it will not succumb to ordinary doses of salines like the stomach strongyle; moreover, the little leech-like wounds will probably bleed after the parasites have been compelled to abandon their hold. Prevention is better than cure. Accordingly, I sought to explain the origin of these creatures, and in what possible ways the germs of the various species could be destroyed, or at least limited in numbers.

As to the drugs and inhalations to be employed, it would be difficult to advise any more effective than those commonly in vogue, the great thing being to effect changes of pasture and ground, to look to the purity of the water-supply, and to supply the best kinds of nourishment after active treatment. The diseased animals should, from the very first, be separated from their companions, because the amount of germ distribution is thereby greatly lessened. They should be at once drenched or treated by inhalation (as the parasitic nature of the attack requires), and the enclosure in which the animals have been temporarily housed should be thoroughly scoured with boiling-hot water impregnated with salt.

The nomenclature of the parasitic diseases of animals is excessively vague. Thus, *apropos* to the case above recorded, I may mention that an American veterinary practitioner appeared to be much shocked that I should have had the temerity to speak of four distinct kinds of lamb-disease. It is in this way that practical men often commit serious mistakes by rolling together disorders that are totally distinct. If it were true that epizoöty in lambs is exclusively due to *Strongylus filaria*, then professionals might aptly speak of the parasitic bronchitis of young sheep as lamb-disease; but we now know that several other helminths prove terribly fatal to lambs, occasioning death in totally different ways. In one set of cases the animals are asphyxiated; in another set they become fatally anæmic; and in a third set they perish from the severity of nervous reflex irritations. Lastly, it may be remarked that, in view of the successful management of the parasitic disorders of animals, the veterinary practitioner must necessarily be guided by the same general principles as the physician. For myself, I may say that I have hitherto designedly withheld many practical hints

which a long experience with human patients suggested, not wishing to appear to dictate to those who are constantly seeing animals. However, since (contrary to my own wishes) it has happened that both professional men and agriculturists have not only invited me to give opinions, but have, at various times, asked me to prescribe, it seems there can have been no impropriety in publishing my views on this subject. Certainly I have had no professional motives to serve.

Of the few non-strongyloid nematodes, one of the commonest is *Trichocephalus affinis*. I have obtained this worm from the giraffe, and the parasite may be said to infest all ruminating animals, not excluding even the camels and llamas. As before remarked, the whipworm has been known to produce severe symptoms in man, and it occasions "scour" in the sheep. The eyes of cattle are occasionally infested by *Filaria lacrymalis* and *F. papillosa*. The last named is the common eye-worm of the horse. On Feb. 27th, 1875, Dr Edward L. Moss, of H.M.S. "Alert," brought me three examples of a nematode which I referred to *Filaria terebra*. Dr Moss obtained these parasites in 1874, during the time that he had charge of the Naval Hospital at Esquimalt, Vancouver's Island. They occupied the abdominal cavity of the black-tailed deer (*Cervus columbianus*). The worms were mostly found lying amongst the coils of the small intestine. They were not attached to the peritoneal membrane. Dr Moss had shot seventeen deer in all, the males and females being in about equal proportion; nevertheless, not one of the bucks showed any trace of the presence of these entozoa. This absence of parasites in the male deer is noteworthy. Hitherto the worm appears to have been observed in the red deer (*C. elaphus*), and by Natterer in three species of American roe (*C. rufus*, *C. simplicicornis*, and *C. nambi*). Two of the worms measured each about 2½″ in length, the third exceeding 3″. They displayed in profile two prominent oral papillæ. Probably there were four of these processes, such as Dujardin described in his *Filaria cervina*, which, according to Diesing, is a synonym. They all possessed spirally twisted tails.

Amongst the arachnidan parasites of ruminants having entozoal habits are *Pentastoma denticulatum* and *P. constrictum*. The former larval worm is excessively common in cattle, sheep, deer, and antelopes. According to Rhind, the adult worm (*P. tænioides*) also infests the sheep. The *P. constrictum* has

hitherto only been found in the giraffe. On the 10th February, 1859, I obtained numerous examples (*P. denticulatum*) from a bubale (*Antilope bubalis*) which died at the Zoological Society's Gardens. The greater number occupied the surface of the lungs and intestines; some few, however, were enclosed in cysts beneath the pleura. In the spring of 1860 I also procured several specimens from the abdomen of a cape guevi (*Cephalopus pygmæus*).

The ectozoa of ruminants have received much attention, but I can merely indicate the known forms. Following Mégnin's classification we have three well-marked varieties of the acarine genus *Sarcoptes* (*S. scabiei*, var. *ovis*, var. *capræ*, and var. *cameli*), two varieties of *Psoroptes* (*P. longirostris*, var. *bovis* and *ovis*), and *Chorioptes spathiferus*. This last is the true mange mite of the ox (or *Symbiotes bovis* of Gerlach). A variety of the follicle mite infests the sheep (*Demodex folliculorum*, var. *ovis*). Numerous species of tick (*Ixodidæ*) have been more or less fully described. Of these we have the Carapartos of the Portuguese (*Ixodes bovis*), attacking cattle; the *I. reduvius*, attacking sheep; the *I. plumbeus*, said to attack lambs; the *I. albipictus* and *I. unipictus*, found on the moose-deer. Probably this species also attacks cattle. A most horrible arachnidan is found on camels. I allude to *Galeodes araneoides* belonging to the *Solpugidæ*. This parasite will bite severely any person who attempts to dislodge it from the bearer. Turning to the insects, we find ruminants liable to be annoyed alike by flies (*Diptera*), fleas (*Aphaniptera*), and lice (*Hemiptera*). Various species of four different families of flies are apt to prove troublesome. Of the *Œstridæ*, attacking the ox, we have *Hypoderma bovis*, whose larvæ form tumours or warbles on the back; also *H. lineata*, *Dermatobia noxialis*, and *Cephenomyia bovis* (mihi). The larvæ of the latter reside at the root of the tongue and adjacent parts. In the sheep we have *Œstrus ovis*, *Œ. purpureus*, and *Hypoderma lineata*. Various species also attack goats and antelopes. Dr Kirk presented me with specimens of Œstrus from the frontal sinuses of a harte-beest or caama, and they have also been obtained from the sassabe, the saiga or colus, from the gnoo, and from the brindled gnoo, kokoon or gorgon. Mr Charles Danford presented me with several bots from an ibex. One or more species of *Hypoderma* have likewise been removed from the gazelle and other antelopes. The deer tribe are much attacked by bots. In the red deer we have *Hyp. actæon*

and *H. diana*, a species also infesting the elk. The throat-grubs are *Ceph. rufibarbis* and *Pharyngomyia picta*; another species, also occurring in the fallow deer, *Ceph. ulrichii*, infests the elk, and *C. stimulator* the roe, the last-named deer being also infested by *Hyp. diana*. A throat-fly infests the reindeer, which is also frequently attacked by *Hyp. tarandi*. Specimens of the latter worm have been obtained by Dr Murie at the Zoological Gardens. The Hunterian Museum also contains these and other species of bots, presented by myself in Mr Andrew Murray's name. A subcutaneous bot has been found in the musk-deer. A throat-bot (*C. maculata*) infests the dromedary.

In regard to the so-called free dipterous parasites and other noxious insects that attack ruminants, their name is legion. One of the worst is the tsetse (*Glossina morsitans*), immortalised by Livingstone. Of the *Muscidæ* we have the ox-fly (*Musca bovina*), the sheep-fly (*M. cæsar*), and the executioner (*M. carnifex*). Of the *Tabanidæ* we have *T bovinus* and *T. autumnalis*, *Chrysops cæcutiens*, and the allied *Asilus crabroniformis* (*Asilidæ*). Amongst the specially noxious insects must also be placed *Stomoxys calcitrans* and *Rhagio columbaschensis*. This fly proves fearfully destructive to cattle in Hungary and Servia. Lastly, I can only further mention the common *Melophagus ovinus*. This is nothing more than a gigantic louse, which from long use agriculturists and veterinarians persist in calling the sheep-tick. It belongs to the *Hippoboscidæ*, the members of which family only attack quadrupeds and birds. As regards the lice (*Anoplura*), I have to mention *Hæmatopinus vituli* of the calf, *H. eurysternus* of cattle, and *H. stenopsis* of the goat; also *Trichodectes scalaris*, *T. sphærocephalus*, and *T. capræ*. These infest the ox, sheep, and goat, respectively.

For some account of the protozoal parasites (*Psorospermiæ*, &c.) infesting the flesh of ruminants I must refer the reader to Book I, Section IV, Part VI of this treatise.

Bibliography (No. 49).—(Anonymous), "On the Hydatid in the Brain of Sheep," from 'Journ. de Méd. Vét.,' in 'Veterinarian,' vol. xxviii, p. 461, 1855.—(*Idem*), "Note on the 'Rot in Sheep,'" 'Veterinarian,' vol. xxxvi, p. 100, 1863.—(*Idem*), "On the Hydatid, or Tumour of the Brain (of Sheep)," under sig. of "Ben Ledi," in 'Veterinarian,' vol. xii, p. 467, 1839.—(*Idem*), "Note on Rot in Sheep, Cattle, and Hares," from the 'Bristol Mirror and Scotsman,' in 'Veterinarian,' vol. xxxvi, pp. 156–7, 1863.—(*Idem*), "Tapeworm Epizoöty in Notting-

hamshire," 'Brit. Med. Journ.,' 1858.—(*Idem*), "Prevalence of Rot in Sheep," from 'Carlisle Journ.,' in 'Edin. Vet. Rev.,' 1863.—*Baillet*, "Filariæ in the Eye of an Ox," from 'Journ. des Vét. du Midi,' in 'Veterinarian,' vol. xxxi, p. 703, 1858.—*Barnett, J.*, "Hydatids in the Liver of a Cow," &c., 'Veterinarian,' 1865, p. 236.—*Beale, L. S.*, "On Entozoa (?) in the Muscles of Animals destroyed by the Cattle Plague," 'Med. Times and Gaz.,' Jan. 20, 1866, p. 57; see also "Annotation," 'Lancet,' Jan. 13, 1866, p. 45, and 'The Microscope in Medicine,' 4th edit., 1878.—*Beneden* (see Van Beneden).—*Böllinger, O.*, "*Echinococcus multilocularis* in der Leber des Rindes," 'Deutsch. Zeitschr. f. Thier med.,' ii, 1876, s. 109.—*Brauer* (see Bibl. No. 50).—*Bugnion, E.*, "Sur la pneumonie vermineuse des animaux domestiques," 'Compt. Rend. de la réunion de la Soc. Helvet.,' Andermatt, 1875.—*Chaignaud*, "Worms in the Eyes of Oxen (with remarks by Desmarets)," from the French, in 'Veterinarian,' vol. i, p. 77, 1828.—*Cobbold*, "Descr. of a new Trematode from the Giraffe," 'Rep. of Glasgow Meeting of Brit. Assoc.,' 1854, and in 'Edin. New. Philosoph. Journ.,' 1855.—*Idem*, "On Flukes," 'Intellectual Observer,' Feb., 1862.—*Idem*, "The common Liver Entozoon of Cattle," *ibid.*, March, 1862.—*Idem*, "The Whipworm of Ruminants," *ibid.*, Dec., 1863.—*Idem*, "Parasite-larvæ," *ibid.*, March, 1863.—*Idem*, "On the Measles of Cattle and Sheep" (see various papers quoted in Book I, Bibl. No. 13).—*Idem*, "On the Cattle-Plague Bodies (spurious Entozoa)," see Bibl. No. 41.—*Idem*, "On the Fluke Parasites of our Food-producing Ruminants," Lect. iv of the Cantor series, pub. in 'Journ. Soc. Arts,' 1871.—*Idem*, "Remarks (&c.) in ref. to the Management of Sheep suffering from Nematoid Worms," 'Veterinarian,' Oct., 1876.—*Idem*, "Record of preliminary Experiments with the Eggs and Embryos of the Husk-producing Strongyle of the Calf," *ibid.*, Dec., 1875.—*Idem*, in 'Entozoa,' pp. 145–183; also in 'Manual,' and in the chap. on "Parasitic Diseases" contributed to 'Williams' Principles of Vet. Med.'—*Idem*, "Remarks on Prof. Perroncito's Researches," 'Veterinarian,' Dec., 1877.—*Idem*, 'Amphistomes of the Ox,' see Bibl. No. 51.—*Cooper, J.*, "Three Cases of Cœnurus in Calves," 'Veterinarian,' 1865, p. 357.—*Copeman, A.*, "Hydatids in the Brain of Lambs," 'Vet. Record,' vol. iii, p. 337, 1847.—*Cox, W.*, "Tænia in Lambs," 'Veterinarian,' vol. xxviii, p. 446, 1855.—*Creplin*, fig. of *Amphist. crumeniferum*, in 'Wiegmann's Archiv,' 1847, tab. ii, s. 30.—*Crisp, E.*,

" On the ' Lamb-disease,' of which Parasites in the Lungs are generally the Cause or Consequence," repr. from ' Journ. of Bath and West of England Soc.,' in July to October Nos. of ' Edin. Vet. Rev.,' 1863.—*Idem*, " Note on *Str. filaria*," ' Proc. Zool. Soc.,' 1856.—*Danford* (see Cobbold, Bibl. No. 52).—*De Reck*, " On the Draconcule (*Strong. filaria aut veinulosus ?*) of Lambs," from ' Ann. de Logelin,' in ' Veterinarian,' vol. v, p. 521, 1832.—*Dupleune*, " Hydatids in the Brain of an Heifer," from ' Mém. de la Soc. Vét. du Calvados,' in ' Veterinarian,' vol. ix, p. 115, 1836.—*Dupuy*, " An Hydatid in the Lumbar portion of the Spinal Marrow of a Lamb, aged eighteen months," from ' Journ. Théorique et Prat.,' in ' Veterinarian,' vol. iv, p. 285, 1831.—*Engelmeyer*, ' Thierarztliche Wochenschrift,' 1850, p. 191.—*Findeisen*, "Ech. in der Lunge," 'Repert. f. Thierheilkund,' 1875, s. 48.—*Fry, J.*, "Worms in the Trachea (of cattle)," ' The Hippiatrist,' vol. iii, p. 5, 1830.—*Furstenberg*, " On *Pent. tænioides* of the Sheep," ' Edin. Vet. Rev.,' 1863. —*Gamgee, J.*, " On Parasitic Diseases," extr. from his ' Rep. to the Privy Council,' ' Edin. Vet. Rev.,' Dec., 1863.—*Idem*, " On Cattle Diseases (including those produced by Entozoa)," from letters in the ' Times ' of Oct. 22, Nov. 10 and 13, &c.; in ' Edin. Vet. Rev.,' Dec., 1863.—*Idem*, " On Diseased Meat (especially in relation to Trichina)," ' Pop. Sci. Rev.,' Jan., 1864.—*Idem*, " On Sturdy in Sheep (with figs. from Van Beneden, Leuckart, and Cobbold)," ' Edin. Vet. Rev.,' vol. i, p. 440, 1859.—*Idem*, " Gleanings from the Researches of Eschricht, Haubner, A. Thomson, &c., respecting the Origin and Development of the Entozoa," ' Veterinarian,' 1855.—*Giacomini* (see Bibl. No. 13).—*Gulliver*, " On the Structure of the Entozoa belonging to the genus Cysticercus," ' Med.-Chir. Trans.,' ' Lond. Med. Gaz.,' and ' Lancet,' 1840–41.—*Idem*, " Notes on the Ova of *Dist. hepaticum*, and on certain Corpuscles obtained from the genus Cysticercus," ' Proc. Zool. Soc.,' March, 1840, and in ' Ann. Nat. Hist.,' vol. vi, 1841; also ' Month. Journ. Med. Sci.,' vol. ii, 1842, and ' Micros. Journ. and Struct. Rec.,' p. 95, 1842.—*Hewlett* (see Bibl. No. 13).—*Holmes, J.*, " Filaria in the Bronchi of a Calf," ' Vet. Rec.,' vol. i, p. 125, 1845.—*Hunter, J.*, " Ileum of a Ruminant containing Acephalocyst Hydatids;" see description of preparation No. 863 in the ' Catalogue of Mus. Roy. Coll. Surg. Lond.' (" Pathology," vol. ii, p. 201), 1847.—*Idem*, " Hydatid in the Humerus of an Ox " (*ibid.*, prep. No. 864).—*Idem*, " On

Hydatids of the Sheep," in supp. to his paper on 'Human Hydatids,' in 'Trans. of Soc. for the Improvement, &c.,' vol. i, 1793, p. 34.—*Huxley*, "On the Anatomy and Development of Echinococcus (from a Zebra)," 'Proc. Zool. Soc.,' and 'Ann. Nat. Hist.,' 1852.—*Karkeek, W. F.*, "Notes on the *Rot* (or *iles* of the Cornish graziers)," 'Veterinarian,' vol. iv, p. 573, 1831. —*King, E.*, "On the Propagation of Rot (by means of the eggs of *Fasc. hepatica*) in Sheep," 'Veterinarian,' vol. ix, p. 95, 1836. —*Krabbe*, "Husdyrenes Indvoldsorme," 'Tidsskrift for Vet.' (See also my notice of the memoir in 'Lond. Med. Rec.' for 1872; repr. in 'Veterinarian,' May, 1873.)—*Küchenmeister* (see Bibl. No. 13).—*Leaver, T.*, "Cases of the Husk (from worms) in Cattle," 'Veterinarian,' vol. ii, p. 355, 1829.—*Lepper*, "Hydatids in the Kidney of a Lamb (with remarks by Prof. Varnell)," 'Veterinarian,' vol. xxxvi, p. 524, 1863.—*Lewis* (see Bibl. No. 13).—*Lord, J.*, "On some of the Parasites principally affecting Ruminants," 'Trans. Vet. Med. Assoc.,' 1842–43.—*Masse* (see Bibl. No. 13).—*Mayer, T.*, "On Hoose in Cattle (from Filaria)," 'Veterinarian,' vol. xiii, p. 227, 1840.—*M'Call, J.*, "On Sturdy in Sheep," *ibid.*, vol. xxx, p. 267, 1857.—*Mégnin, P.*, "Le *Str. minutissimus*," 'Bullet. de la Soc. Centrale Vét.,' in 'Rec. de Méd. Vét.,' July, 1878, and in 'Ann. de Méd. Vét.,' Oct., 1878, p. 563.—*Moorcroft*, "Brain Hydatids," 'Med. Facts and Observ.,' 1792.—*Morton, W. J. T.*, "On the Entozoa affecting Domesticated Animals, and particularly on *Fasc. hepatica* or Liver Fluke in Sheep," 'Veterinarian,' vol. xii, p. 735, 1839.—*Mosler* (see Bibl. No. 13).—*Murie, J.*, "On the occurrence of *Œstrus tarandi* in a Reindeer in the Zoological Society's Gardens," 'P. Z. S.,' 1866, with woodcuts.—*Idem*, "On a Leech (Trocheta) found in the Viscera of a Molluscan Deer (*Cervus moluccensis*, Müller)," *ibid.*, 1865.—*Numan*, "Over den Veelkop-blaasworm der Hersenen" (this beautifully illustrated memoir, in the 'Trans. of the Dutch Soc. of Sciences,' supplies an elaborate bibliography of continental writings on *Cœnurus cerebralis*—T. S. C.), 'Œrste Kl. Verh.,' 3e Reeks, 2e Deel, p. 225 *et seq.*—*Oliver* (see Bibl. No. 13).—*Padley, G.*, 'On Entozoa from a Sheep;' see Sandie.—*Parsons*, "On Diarrhœa in Lambs (with bronchial worms)," 'Veterinarian,' 1855, p. 685. —*Patellani*, "Sturdy in Cattle," from 'München Jahresbericht,' in 'Veterinarian,' vol. xxx, p. 81, 1857.—*Pellizzari* (see Bibl. No. 13).—*Perroncito* (see Bibl. No. 13).—*Pourquier* (see Bibl. No. 13).—*Ralph, T. S.*, "On the Parasitic Nature of

Pleuro-pneumonia," &c., two papers in 'Austr. Med. Journ.,' 1865.—*Ranke*, "Pulmonary Entozoic Disease of Sheep," 'Path. Soc. Trans.,' 1858; see also 'Veterinarian,' vol. xxx, p. 708, 1857.—*Raynaud*, "A Word on the Cachexia, or Rot in Ruminants," trans. from the 'Journ. des Vét.,' by W. Ernes, in 'Veterinarian,' vol. xxxiii, p. 488, 1859.—*Read, R.*, "Destruction of Strongylus and Filaria in the Bronchial Passages of Calves, through nasal inhalation of ether, chloroform, oil of turpentine, or rectified oil of amber," 'Veterinarian,' vol. xxi, p. 604, 1848.—*Reck* (see De Reck).—*Reed, R.*, "Congenital Hydatids in a Lamb," 'Veterinarian,' vol. viii, p. 551, 1835.—*Rhind*, "Description of a species of Worm (Pentastoma) found in the Frontal Sinus of a Sheep," 'Farrier and Naturalist,' vol. iii, p. 277, 1830, and 'Lancet,' 1829.—*Robertson*, "Remarks on Tænia in Lambs," 'Rep. of Scottish Med. Vet. Soc.,' in 'Veterinarian,' 1875, p. 80.—*Rochard* (see Bibl. No. 13).—*Rose, C. B.*, "On Cœnurus and Acephalocysts," 'Lond. Med. Gaz.,' vol. xxiv, p. 525, 1844.—*Idem*, "On the Anat. and Physiol. of the *Cysticercus tenuicollis*," 'Roy. Med.-Chir. Soc. Trans.,' and 'Lancet,' 1848.—*Idem*, "On the Vesicular Entozoa, and particularly Hydatids," 'Lond. Med. Gaz.,' vol. xiii, p. 204, 1833-34.—*Sandie* (with *Padley*), "On Entozoa in the Lungs of a Sheep," 'Ann. Nat. Hist.,' 1849.—*Schwarzmeier*, "Die Trepanation des Rindes bei Cœnurus," 'Wochenschr. f. Thierheilk.,' 1875, s. 295.—*Shenton*, "Worms from the Stomach of a Cow," 'Veterinarian,' 1844, p. 487.—*Siedamagrotzky*, "Hydatids in the Liver of a Cow," 'Bericht üb. das Veterinawesen im Kön. Sachsen,' 1875, s. 29.—*Simonds, J. B.*, "Death of Sheep from Worms in the Stomach (abomasum), being remarks on Mr. Haywood's case," 'Veterinarian,' vol. xxxiv, p. 525, 1861.—*Idem*, 'The Rot in Sheep, its nature, cause, treatment, and prevention,' London, 1862.—*Idem*, "On Filariæ in the Bronchi of Calves," 'Trans. Vet. Med. Assoc.,' 1843, p. 517.—*Idem*, "On Strongylus in the Bladder and Intestines," *ibid.*, 1843.—*Idem*, "On Hydatids of the Liver of a Sheep (Mr Scruby's case)," *ibid.*, p. 331.—*Idem*, "On Disease of the Mesenteric Artery from Strongyli within the Vessel," 'Path. Soc. Trans.,' 1854.—*Idem*, "Lecture on the Nature and Causes of the Disease known as Rot in Sheep," vol. xxxiv, p. 274, 1861.—*Spence, G. W.*, "On Œstrus of the Ox," 'Edin. Med. Journ.,' 1858, and 'Edin. Vet. Rev.,' vol. i, p. 400.—*St Cyr* (see Bibl. No. 13).—*Stoddart, J.*, "Case of Hydatids in the Liver (of a Cow),"

'Veterinarian,' vol. xi, p. 637, 1838.—*Sutton* (Lecture), 'Gardiner's Chronicle,' June 29, 1872.—*Sylvester, F. R.*, "Cases of Parasites infesting the Brains and Intestines of Lambs," 'Vet. Rec.,' vol. ii, p. 40, 1846.—*Thudichum* (see Bibl. No. 13). —*Idem*, "Echinococci from the Sheep's Lungs," 'Rep. Med. Soc. Lond.,' in 'Assoc. Med. Journ.,' 1856, p. 195.—*Tommasi* (see Bilb. No. 13).—*Van Beneden*, "On the Development of Cœnurus," from 'Comp. Rend.,' in 'Ann. Nat. Hist.,' vol. xiv, 1854.—*Watson, K. W.*, "Experiment for the Cure of the *gidd* (Cœnurus) in a Sheep," 'Lond. Med. Repos.,' 1815.—*Willemoes-Suhm*, in 'Sieb. and Köll. Zeitschr.,' Bd. xxv, s. 176.—*Wilson, E.*, "On the Anatomy of *Trichocephalus affinis*," 'Vet. Rec.,' 1846.—*Wymann*, "Note on Filaria in the Bronchi of a Sheep," see Anon. on "Entozoa and Parasites," in 'Amer. Journ. Sci.,' vol. xxxix, p. 183, 1840.—*Youatt*, "On Hydatids in the Sheep (symptoms, prevention, treatment, &c.)," 'Veterinarian,' vol. ii, p. 519, 1834.—*Idem*, "On the peculiar Bronchitis in young Cattle, accompanied by Worms in the Bronchial Passages," part of lecture, in 'Lancet,' 1832.—*Idem*, "Hydatids in the Brain of a St Domingo Goat," 'Veterinarian,' vol. ix, p. 443, 1836.—*Idem*, "Bronchitis from Worms (in Cattle)," *ibid.*, vol. vi, p. 177, 1833.—*Idem*, "Hydatids in the Brain (in Cattle)," *ibid.*, vol. vii.—*Yvart*, "Brain Hydatids," *ibid.*, 1828, p. 19.—*Zahn*, "Lungenwürmer beim Reh," 'Œsterr. Vieteljahrschr. f. w. Vet.,' 1875, s. 125.—*Zurn* (see Bibl. No. 13).—For further references to the literature of Hydatids in Animals, see Bibliography No 20, *o*, in the first half of this work.

Part IX (Solidungula).

It will naturally be expected that I should give a full account of the parasites of the solipedal, solidungulate, or equine mammals. As regards the horse I regret that I cannot meet this expectation in so complete a manner as the subject deserves; nevertheless, with the aid of an extended bibliography the summary here offered will be found to be tolerably exhaustive. At all events I think I may say that no similar record has hitherto been attempted.

The liver fluke (*Fasciola hepatica*), though not very frequent in the horse, is not uncommon in the ass. In dissecting-room subjects at the Royal Veterinary College it is often encountered.

In France it was originally found in the horse by Daubenton. As I learn from Sonsino, Dr. Abbate Bey recently recorded a similar find at Cairo. In solipeds generally the liver fluke appears to be almost harmless, for, notwithstanding the frightful ravages produced by rot amongst a variety of animals besides sheep, we have no evidence of the destruction of horses from this cause. In the German outbreak of 1663-65 multitudes of cattle and deer perished, and in the French outbreak of 1829-30 five thousand horned beasts succumbed in the arrondissement of Montmédy alone. In neither of these epizoötics were the solipeds affected. More importance attaches itself to the study of the amphistomatoid flukes. These parasites, though in a scientific sense only recently discovered in equine bearers, have been long known to the natives of India. They appear to be capable of producing serious intestinal irritation. I have described two forms (*Amphistoma Collinsii* and *A. Coll.*, var. *Stanleyi*), which infest the colon. The specimens sent to Prof. Simonds from India by Mr Stanley, V.S., were much larger than those sent to me from Simla by Mr Collins, V.S., some ten years later (1875). As in all other amphistomes obtained from the intestines of elephants and cattle, the worms, when fresh, were of a bright brick-red color. By the natives of India these parasites are called *Masuri;* but no description of the worms had been published prior to the account which I gave of the contributions forwarded by Major-General Hawkes, Mr Collins, and Mr Stanley.

I shall have occasion to speak of the elephant's *Masuri* further on; but in the meantime I must remark that the generally received notion as to the parasitic cause of the earth-eating propensities of various animals seems to have some foundation in fact. Not alone from Major-General Hawkes in Madras, from Mr Folkard in Ceylon, and from various other trustworthy sources, have I been informed of this habit on the part of Indian horses, but Dr Rowe told me that Australian horses, and even sheep, infested with stomach-worms, are in the constant habit of consuming large quantities of sand. From all the facts that have come before me, I am inclined to think that gastric or intestinal irritation, however brought about, may induce the habit in question, parasites being only one of the many sources of irritation giving rise to symptoms of colic in solipeds and pachyderms alike. At all events the African elephants at the London Zoological Society's Managerie, as

repeatedly witnessed by myself, are in the habit of swallowing large quantities of soft mud during the summer months, but no traces of *masuri* have as yet been detected in their fæces.

When by letter I informed Major-General Hawkes of an interesting find by Mr Collins of *about a thousand* Amphistomes in the colon of a horse that had died at Simla, the announcement called forth a reply which is sufficiently instructive to be quoted. Writing from Secunderabad in July, 1875, he says, respecting this "find :"—"Your statement has incidentally thrown light upon a subject which has puzzled many of us in this country. It occasionally happens that a horse, on being opened after death, is found to have accumulated in his intestines large quantities of sand and gravel. In a recent case this accumulation amounted to 14½ lbs. Until recently it was always held that this gravel or sand could only be introduced with the animal's food. All grain in this country is trodden out by bullocks on an earthen floor, and the grain undoubtedly contains a proportion of sand and gravel derived from this source. Although this *ought to be* carefully washed out before it is given to the horse, still, owing to the carelessness of the native horse-keepers, this cleaning is, I expect, often omitted. In the daily 'feed' of eight or ten pounds of grain given to each horse the utmost quantity of sand or gravel that could be found admixed therewith would not probably exceed two or three ounces; consequently it would take from 77 to 116 days to accumulate so large a quantity as 14½ lbs. Now, the advocates of the theory of the gradual accumulation of sand in this way have never been able to explain why the grain, grass, hay, and other ingesta should pass in the ordinary way through the intestines, whilst this sand or gravel remains behind. One can understand the possibility of such substances as wool, hair, or similar matters concreting in the alimentary canal, though I believe they are usually found in the stomach, and not in the intestines; but how a most incohesive substance like sand can possibly accumulate in the gradual way required by their theory I have never heard even plausibly explained. On the other hand, the fact that horses are often excessively addicted to eating earth is well known; and if my memory serves me correctly, it was found necessary, about twenty years ago, to remove the mud-walls of the pickets surrounding some of the horses of a mounted corps in this presidency in consequence of this habit.

Now, given the fact that the amphistoma has been found in the horse (as your specimens prove), may we not fairly suppose it possible that the animal resorts to the same mode of ridding himself of this parasite as does the elephant? and also, would it not in a much more natural manner account for the large quantity of gravel or sand found in the intestines than does the theory of gradual accumulation? Reasoning from analogy, as in the case of the elephant, this eating of earth in the horse would be an instinctive effort on the part of the "host" to rid himself of the parasite. This self-taken remedy is doubtless in many cases quite effectual, *though unnoticed.* The fatal cases are probably those in which the horse has either overdone the remedy or where the system was too debilitated to carry off a quantity of sand or gravel that would otherwise have safely passed through the intestines of a horse in more robust health. The actual fact must, of course, be verified by careful investigation."

Closely allied to the Masuri is an amphistome which I originally named *Gastrodiscus Sonsinoii*, but which should be altered as opposite (Fig. 62). It exceeds $\frac{1}{2}''$ in length and $\frac{1}{3}''$ in breadth (16 mm. long by 10 broad). Its discovery by Dr Sonsino was one of the results of his examination of sixteen carcases of solipeds that died during the Egyptian plague of 1876. Specimens having been forwarded

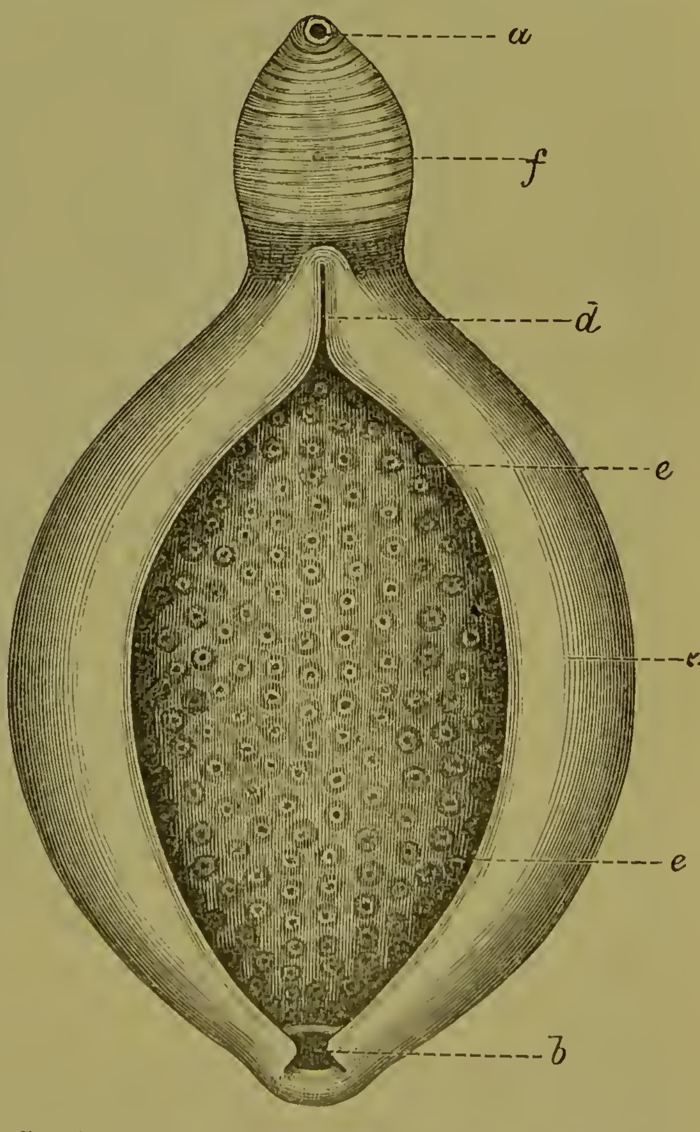

FIG. 62.—*Gastrodiscus Sonsinonis.* *a*, Mouth; *b*, caudal sucker and posterior mesial cleft; *c*, left lip of the gastric disk; *d*, anterior mesial cleft; *e*, *e*, gastric suckerlets; *f*, reproductive papilla. Enlarged. Original.

to Panceri, Von Siebold, Leuckart, and myself, most of us at once agreed that the worm was new to science. Pointing to the genera, *Notocotylus* and *Aspidocotylus*, I explained its close affinity to the latter more particularly. Whilst *Notocotylus* has fifty supplementary suckers on its back, *Aspidocotylus* has nearly two hundred small ventral suckers seated on a convex disk. In *Gastrodiscus* a still larger number of suckerlets are placed in the deep concavity of a large gastric disk formed by the outstretched and inrolled margins of the body of the parasite. Zoologically speaking, the odd thing about this singular worm lies in the circumstance that its nearest fluke-relation, so to speak (*Aspidocotylus mutablis*), dwells in a spiny-finned fish (Cataphractus); and this fish itself forms an aberrant genus of the family to which it belongs (Triglidæ). From what has been said it will be seen that our *Gastrodiscus* must not be confounded with *Cotylegaster cochleariform* (or with its synonym *Aspidogaster cochleariformis*), to which parasite Von Siebold was, I believe, induced to refer it. Like most of the true amphistomes, the worm in question infests the intestines. Although discovered by Sonsino at Zagazig in plague-affected corpses, there is no reason to suppose that this helminth was in any way etiologically connected with the Egyptian epizoöty.

The tapeworms of the horse are of great interest practically. Excluding Sander's *Tænia zebræ*, which was doubtless *T. plicata*, at least five species have been described, but they may probably be all reduced to two distinct forms and their varieties. Whilst *Tænia plicata* acquires a length of three feet, the strobile of *T. perfoliata* never exceeds five inches. The lobes at the base of the head in the latter are distinctive. The former is usually confined to the small intestine, but the perfoliate worm often occupies the cæcum and colon in great numbers. As regards *T. mamillana*, I may say that neither Gurlt's descriptions nor his figures are convincing. The worm is, I believe, identical with *T. perfoliata*. In like manner, after going into the matter with some care, I am accustomed to speak of Mégnin's *T. inerme* as *T. perfoliata*, var. *Mégnini*, and of Baillet's *T. innomé* as *T. perfoliata*, var. *Bailletii*. I have examined great numbers of equine tapeworms, but whether my determinations on this point are correct or not, the case recorded by Mégnin is of remarkable interest. Clinically, indeed, it is not entirely unique, since a somewhat similar case has been recorded by Mr Poulton. In Mégnin's equine patient the autopsy revealed the presence

of 200 bots, 153 lumbricoids, upwards of 400 oxyurides, and several thousand palisade worms, besides numerous tapeworms. In Mr Poulton's patient large quantities of tapeworms were found in the duodenum (and in large sacs of the walls of other sections of the small intestine), and also myriads of the little four-spined strongyle, in addition to about a score of palisade worms. Both Mégnin's and Poulton's patients died suddenly; but the great interest attaching to Mégnin's case arises from the boldness of manner in which the French *savant* interprets the phenomena of the intestinal sacculation in relation to the development of the tapeworms. M. Mégnin assumes that the sacs are due to the formation of polycephalous or cœnuroid scolices. Without contradicting Mégnin's ingenious interpretation of the phenomena in question, I may say that the difficulty I have in accepting his view arises from the circumstance of the rarity of the occurrence of these sacs. In Poulton's case of *Tænia perfoliata* the sacs were present, and they were productive of similar results; but in the scores of other recorded cases of sudden death from the same species of tapeworm (as published by Mr Rees Lloyd, and myself), the presence of such sac-formations is not once mentioned. To be sure, their presence may have been overlooked, but this is scarcely likely, seeing the great care taken by Mr Lloyd in conducting the autopsies. I cannot dwell upon the subject at greater length. The presence of so many sexually-immature strobiles, combined with the existence of the intestinal wall sacs, certainly does seem to point to the existence of cœnuroid bladder-worms, but until the existence of the polycephalous scolex be actually demonstrated one must be cautious in concluding "that the horse nourishes at the same time the strobila and scolex of the unarmed tapeworm." Practically, we now know for certain that not only are tapeworms capable of producing a fatal issue in isolated cases, such as those recorded by Mégnin and Poulton, but that they may also be productive of disastrous epizoöty, as proved by Mr Lloyd in the case of Welsh mountain ponies.

In this connection I may perhaps be pardoned for saying that this discovery in 1875 was one of the practical results directly issuing from the publication of my 'Manual' in 1874. The attention of the veterinary profession having been called to the subject of parasitic epizoöty, Mr Lloyd was the first to make search for helminths amongst some

few of the carcases of the hundred and more equine animals that perished in South Wales. Two totally distinct epizoötics prevailed. In the Beacons district tapeworms alone were the cause of death, whilst in the Deangunid district scores of animals perished from strongyles. In another district a hundred animals perished from tapeworms. These parasites I identified as examples of *Strongylus tetracanthus* and *Tænia perfoliata.* Taking all the helminthological facts together we have made a great advance both in hippopathology and equine epidemiology; and, as I observed at the time, the scepticism which not unnaturally still exists (in reference to entozoa as a frequent cause of death amongst animals, both wild and domesticated) will sooner or later be dispersed by that wider attention to the subject which our labors have invoked.

In relation to equine disease the facts brought forward are too important to be dismissed in a single paragraph. As two distinct kinds of parasitic epizoöty were discovered, the circumstances connected with their separate detection must be noticed at greater length. Further on, I shall again deal with the helminthiasis due to strongyles. It was on the 17th of April, 1874, that I received from Mr Lloyd, of Dowlais, Glamorganshire, a communication calling my attention to a fatal epizoötic affecting ponies. He supposed the outbreak to be due to parasites. On the following day I also received a parcel containing portions of the lower intestines, which had been removed from one of the diseased animals. The victim in question, a pony mare, had died on or about the 12th of April, at Llangunider, Breconshire. Mr Lloyd states in his letter that he "presumes" that the pony's death was caused "by the presence of small worms," examples of which he now forwarded for the purposes of identification and investigation. He also sent some equine tapeworms. Mr Lloyd had already inferred that his small worms were "strongyles;" and in regard to the tapeworms he says:—"This species of parasite has caused, or is supposed to have caused, the death of at least one hundred mountain ponies." The investigation being immediately proceeded with, I may so far anticipate my record of the results obtained as to state at once that the facts observed by me confirmed Mr Lloyd's suspicions—proving, beyond a doubt, that the pony above mentioned had succumbed to injuries inflicted by myriads of minute strongyles. Not only did I find the fæcal matter of the colon loaded with mature strongyles, but

the walls of the intestine were also occupied with encysted and immature forms of the same nematode species. To such an extent had infection taken place, that I was enabled to count no less than thirty-nine strongyles within the space of the one fourth of a square inch. All parts of the sections of the colon under examination were almost equally invaded; so that, taking the average, I am clearly within the mark in saying that every square inch of the gut yielded at least one hundred parasites. The walls of the entire colon must therefore have been occupied by tens of thousands of these creatures, to say nothing of the scarcely less numerous examples lying free or lodged within the fæcal contents of the bowel.

In a second and more extended communication, sent in reply to inquiries as to the cestodes, Mr Lloyd (whose letter I have abridged) writes:—"I regret that I cannot give you very full particulars respecting the tapeworms. During the last twelve months mountain ponies grazing on the lower districts of Breconshire, which comprise some of the highest mountains in South Wales, have been dying in great numbers, from what the farmers indefinitely term inflammation. From what I have seen and heard, it appears that there are three causes of death, the tapeworm, the small worms (which I presumed were a kind of strongyle), and catarrhal disorders, such as have been common among horses of late. By far the greater number of deaths (from what I can glean) have been caused by the parasites. In the Ystradfellte or Penderin districts there has been no investigation, although the disease has reigned there for a longer period, about eighteen months, with (from what I have heard) a larger number of deaths than elsewhere; so I shall let these remain for the present, as I have not had an opportunity to see or hear anything authentic about them. In the Talybont district the cause appears to be the small worms (like those I sent). The owner of the animals said that a month ago, when he went to look after his ponies, they were appearing quite well, and looked as well as he could expect them at this season, but he was astonished to find some of them a fortnight ago looking very lean and wasting, and he thought that the weather was the cause of it, yet resolved to see them oftener; the next time he saw them one was dead, and knowing of the loss in the neighbourhood, and fearing he would be a sufferer, he sought aid, applying to me. When I arrived two days following two more were dead, and they presented an emaciated appearance.

The post-mortem examination revealed a healthy condition of the whole of the intestines, save slight thickening of some parts of the colon and rectum, which contained, enclosed in the mucous membrane, in cysts or minute sacs, worms coiled upon themselves. Each cyst, containing one worm, was best seen by transmitted light. The colon was nearly full of fæcal matter, which contained thousands of parasites scarcely visible. The largest were very few in number, not exceeding an inch in length and barely one sixteenth in diameter at the middle portion. They somewhat tapered at both ends. The cæcum was half full of fluid fæces, containing no visible worms; the rectum, with fæces of natural consistence, the examination of which reavealed only two or three evident worms; so that the examination of fæces of living animals giving results like this would not assist the diagnosis, unless suspected. Small intestines—these latter contained about a dozen bots, which were nearly free, but had pierced to the muscular coat. I should think they had participated in the disease. The right lung had been slightly congested; nothing else abnormal to be seen. Possibly congestion of lungs would arise from the distress when pained with worms, for the pony was found on its back with its head in a thicket—it had not appeared to have struggled—with its teeth firmly closed.

"Respecting the animals affected with Tænia, it is remarkable that, as a rule, they are in fair condition. The average time they appear to be troubled with the worms is two months, and the symptoms observed have been many. They are at first seen to be unable to keep up with the other ponies, extending the head and turning the upper lip up, rubbing the quarters, staring coat, suddenly appearing distracted, seizing turf in mouthfuls when being griped or pained, others running away as fast as they can go, or rolling and kicking on the ground for five or ten minutes, then walking away as if nothing had happened, if coming down a slope quickly almost sure to fall headlong, easier caught, not unfrequently coughing, groaning noise, appetite good, and, what is peculiar in some of them, lameness of one of the hind limbs, mostly the near hind leg, with slight knuckling over at fetlock.

"*Post-mortem appearance.*—Abdominal viscera normal, save rectum, which is in some places slightly congested; colon nearly full of fæces, no worms; cæcum, in which worms are alone found, is nearly full of fæcal matter of thicker consistence

than usual, and nearly half made up of worms; stomach half full of partly digested food; heart and lungs healthy; Schneiderian membrane injected; mucous membrane of trachea and part of larger bronchiæ of a more or less livid colour (which may be owing to asphyxia); corner of tongue bitten off; mouth very close.

"Several animals were found at times lying dead together.

"Of the *Tænia* as many as three or four ponies, which some hours previous had been seen grazing unaffected, were found dead on the same spot; and this to my own knowledge, one farmer having lost ten.

"Of the small worms I have been told by a farmer that in his district one of his neighbours had lost twelve ponies."

As I had partly misunderstood my informant's original statement, Mr Lloyd, in a third communication, repeated the evidence, emphatically reminding me that "the ponies affected with tapeworms are in a district six or seven miles distant from those affected with strongyles. Those troubled with tapeworms are in good condition, as a rule, up to death; they are noticed to be troubled generally for two months previous to death, and may be seen at one hour grazing and apparently well, and dead or dying the next hour. As many as four have been found dead at the same spot. In this (the Beacons) district the tapeworms alone have been found and not a single strongyle. In the Deangunid district strongyles only have been found, such as I sent you. The ponies have been noticed ailing for three or four weeks, becoming rapidly emaciated and dying from exhaustion. In tapeworm-affected animals the cæcum is nearly half full of these parasites. The animals thus affected are on the red sandstone formation, whilst those affected with strongyles occur on the limestone formation—the latter affording the drier situation."

Being on the teaching staff of the Royal Veterinary College I was particularly glad to have the authority of an experienced veterinary practitioner to testify to the injuriousness of *Tænia perfoliata* in the horse. Over and over again I had pointed out to the members of my class the desirability of examining the fæces of solipeds where obscure symptoms of intestinal irritation existed. Not only so; at the request of friends I wrote out prescriptions suitable for equine patients suffering from tapeworm. I felt the more indebted to Mr Lloyd, inasmuch as his practical views served to strengthen the propositions I had advanced in

connection with internal parasites as a frequent cause of epizoötics. My views were criticised at the time with a vigour and warmth well worthy of those who are afraid of advancing epidemiological science too rapidly; but it seems that so far from my having overstepped the bounds of moderation in this matter I had, in reality, been too cautious. Certainly it can now no longer be said that "the symptoms created by tapeworms in the horse are of little or no consequence." Here, therefore, I repeat, we have made a clear and rapid advance in our knowledge of helminthic disease; and from the impulse thus given to hippopathology it is only reasonable to look for still further advances in veterinary medicine. By-and-by, the scepticism which not unnaturally exists in reference to entozoa as a frequent cause of death amongst animals, will be dispersed by even yet clearer enunciations regarding the important part these parasites play in the destruction of our most valuable creatures.

Apart from the question incidentally raised by Mégnin as to their origin and mode of development, the presence of larval cestodes in horses cannot be passed over. The common hydatid (*Echinococcus veterinorum*), though not of frequent occurrence, is occasionally productive of fatal consequences. Very interesting cases are recorded by Messrs Henderson and Kirkman, aided by the valuable comments of Professor Varnell. Mr Hutchinson observed an hydatid in a horse's eye, and Mr Vincent noticed lameness, as resulting from hydatids. But one of the most interesting cases of hydatids in solipeds is that described by Professor Huxley, from a zebra that died at the Zoological Gardens in 1852. As stated in Huxley's elaborate memoir (freely quoted in the first part of this work), the liver was found to be "one mass of cysts, varying in size from a child's head downwards." The zebra's death was purely accidental, as it broke its neck while at play in the paddock. The long bladder-worm of the horse (*Cysticercus fistularis*) is entirely unknown to me, and, as before suggested, may be a mere variety of the *C. tenuicollis* of ruminants. An authentic instance of the occurrence of the gid hydatid (*Cœnurus cerebralis*) in the horse is recorded by Gurlt. Lastly, in relation to the question of food, it is worthy of remark that whilst beef, veal, pork, and even mutton, are apt to be measled, the muscle-flesh of horses is not liable to be infested by Cysticerci. This is a fact in favor of hippophagy.

The nematodes of solipeds are very numerous, and first in importance must be placed the palisade worm (*Strongylus armatus*). This worm was known to Ruysch (1721). The old naturalists recognised two varieties (*major* and *minor*). These we now know to be merely the final stages of growth of one and the same entozoon; and in both stages the worm inflicts severe injury upon the bearer, chiefly, however, whilst wandering through the tissues. The palisade worm has acquired notoriety principally on account of its causing verminous aneurism, nevertheless, this pathological change is not, in itself, the most disastrous evil produced by the worm. In the adult state the female reaches a length of two inches, whilst the male rarely exceeds an inch and a half. The posterior ray of the caudal membrane or hood of the male is three-cleft. In both sexes the head is armed with numerous, closely-set, upright denticles, presenting the appearance of the teeth of a circular saw or trephine. The eggs are elliptical and somewhat constricted at the centre, their contents forming embryos after expulsion from both parent-worm and host. The larvæ are rhabditiform, changing their skin, in moist earth, in about three weeks, at which time they part with their long tails. According to Leuckart, they pass into the body of an intermediate bearer before entering the stomach of the definitive or equine host. From the alimentary canal they pass to the blood-vessels, causing aneurism, and thence they seek to regain the intestinal canal, where they arrive at sexual maturity. It is during their migratory efforts that they give rise to dangerous symptoms in the bearer, not unfrequently causing the death of young animals, especially yearlings. In the adult state the worm is also dangerous to the bearer, as it produces severe wounds by anchoring to the mucous membrane of the gut.

The proofs we possess as to the frequency of abdominal, especially mesenteric, aneurism from this source are overwhelming. Prof. Brüchmüller estimated the percentage of aneurismal horses, six years old and upwards, at 91 per cent., and it is a matter of common observation in veterinary dissecting rooms that verminous aneurism is rarely or never absent in the ass. Professors Dick, Simonds, Pritchard, Williams, and many other English and Scotch veterinarians of eminence, have all borne testimony of this kind, and, for myself, I may say that one of the earliest pathological appearances with which I became familiar, some thirty years back, was that presented by mesen-

teric arterial disease of the ass. In relation to fatal colics in the horse the study of verminous aneurism is of the highest moment. On this subject Prof. Friedberger has published some valuable lectures, in which, amongst other points, he incidentally remarks upon the comparative freedom of military horses from aneurism as compared with ordinary laboring horses. This arises partly from the fact that the latter are not cared for to the same extent, dietetically and otherwise; and, moreover, cavalry horses are, as a rule, younger than ordinary working animals. Whilst Friedberger, in his suggestive brochure, does ample justice to the writings of his colleague, Dr Bollinger, it may be said, in like manner, that he does not fail to recognise his great indebtedness to the researches of Leuckart. So practically important, however, do I deem Bollinger's summary of the whole subject in relation to the hippopathological aspects of parasitism, that I feel it desirable to record his conclusions at full length. No professional man having any pretensions to a knowledge of the veterinary art—or, for that matter, to parasitism in relation to sanitation—should remain uninformed on this subject. Dr Bollinger's results are thus stated:

1. The worm aneurism of the visceral arteries of the horse, existing in 90 to 94 per cent. of adult horses, has a general correspondence with the *aneurisma verum mixtum* of man. It is, however, distinguishable from the same by its seat, cause, character of its walls, contents, and mode of termination. The worm-aneurism arises from a parasitism of the palisade worm (*Strongylus armatus*), owing to an inflammatory affection of the arterial walls which it causes, and which one may describe as a recurrent traumatic endo-arteritis. This holds good for all the visceral arteries, with the exception of the abdominal aorta, in which an aneurism may arise from local increase of pressure.

2. The formation and further development of the aneurism is also favored by the narrowing of the arterial calibre, which is caused by the inflammatory swelling of its walls, and also by the contemporaneous formation of a thrombus (clot), this latter still further supporting and exciting the inflammation of the inner coat.

3. Whilst the causes above mentioned (and of these more particularly the continued presence of the palisade worms and the plugging of the smaller arteries by thrombi) favor the growth of the worm-aneurism, the small size of the same, notwithstanding the years it has existed, is explained by the con-

siderable hypertrophy of the muscular layer, by the tough fibrous capsule formed in many cases by the connective tissue of the mesentery, and by the adhesion of the intestines to the perpendicular and free-lying anterior mesenteric artery; in particular this last-named circumstance does not allow of any very considerable shortening of the mesenteric artery, which would necessarily be accompanied by considerable dilatation of the arterial tube.

4. The favorite seat of the worm-aneurism is the trunk of the anterior mesenteric artery, directly at its origin from the abdominal aorta. Most frequently that part of the arterial trunk is dilated from which the arteria ilea, cæcales, and colica inferior (*arteria ileo-cœco-colica*) arise, less frequently the arteria colica superior at its origin, and the arteries of the cæcum and colon in their course in the meso-cæcum and meso-colon. The verminous aneurism also occurs in the cœliac artery (Bauchschlagader), in the posterior mesenteric artery (Gekrös-arterie), in the renal artery, and in the abdominal aorta. A horse is not unfrequently afflicted with several aneurisms of this kind at one and the same time. Thus in one case (described by Bollinger) there were six of these aneurisms affecting the abdominal aorta and its branches in the same horse. The verminous aneurism may occur from the sixth month of life onwards, and with increasing age; the number of horses free from such aneurisms becomes continually smaller.

5. The size of the aneurism varies between that of a pea and that of a man's head. The dilatation is, as a rule, equal on all sides, the form being usually thumb-shaped or bottle-shaped, passing into that of a cone or long oval figure. This general configuration is principally due to the free and moveable situation of the anterior mesenteric artery.

6. In contrast to aneurisms in man, the walls of the worm-aneurism of the horse are almost without exception indurated. In addition to the mesenteric connective tissue, all the arterial coats, and especially the *tunica media*, generally take part in this induration. The hypertrophy of the media, which stands unique in respect of what is known of arterial disease, forms a compensatory action of the arterial wall, analogous to the muscular hypertrophy of the heart in valvular disease. This change in the media points to the fact that in the development of aneurism in man the early disturbance of the nutritive process in the *tunica media* is not a less essential factor than the degeneration of the *tunica intima*.

The changes in the *intima* are the least constant. They present all stages of progressive and retrogressive metamorphosis, from simple induration to ulceration and calcification. In the walls of the verminous aneurism one not unfrequently finds all the pathological changes exhibited by *atheroma* in man. Calcification is a common form of the retrograde process, and, in very rare cases, may pass on to the formation of true bone.

7. In addition to the palisade worms, one almost constantly finds a parietal thrombus contained in the aneurism. It covers the inner wall either partially or completely, being in the latter case perforated for arterial offshoots. This clot may occlude the artery, and it is not unfrequently continued into the arterial branches (peripherally) or into the aorta (centrally). Amongst the various changes that the clot undergoes, organisation of its outermost layer and softening are the most frequent. The constant occurrence of this clot is due to the presence of the worms, to the inflammation, ulcerative and regressive affection of the intima, and to the dilatation of the arterial tube.

8. The palisade worms are seldom absent from aneurisms of the horse. Their not being present is merely an accidental circumstance. On the average, nine palisade worms go to a verminous aneurism, and eleven in the horse. The highest number of worms found in one horse reached 121. Not unfrequently, also, palisade worms, or their coverings in the form of larval skins, are found in the aneurismal walls. The immigration and emigration of the palisade worms out of the intestine into the aneurism, and the reverse, take place probably, as a rule, within the arterial circulation. The path of the worm does not appear to be always the same, inasmuch as they can also wander through the peritoneal cavity. The worms found in the aneurismal walls are probably mostly only strayed specimens.

9. From a comparative pathologico-anatomical point of view, the developmental history of the aneurysma verminosum proves that a circumscribed endo-arteritis can determine the formation of an aneurism.

10. Like the worm-aneurism itself, atheroma of the abdominal arteries arises from a circumscribed acute and subacute endo-arteritis. The histological changes in the secondary atheroma of horses are perfectly analogous to those of the spontaneous atheroma of man. Idiopathic atheroma, as seen in man, does not occur any more in the horse than in the other

domestic animals. Atheroma in the horse is always secondary. To be sure, one observes an idiopathic chronic endo-arteritis in many abdominal arteries of the horse, which, however, never exhibits indications of atheromatous degeneration.

11. In consequence of its position the worm-aneurism of horses is not open to physical examination, and on that account cannot be diagnosed by physical signs; moreover, it offers no characteristic symptoms. Its termination by rupture is extremely rare, the aneurisms of the abdominal aorta being more disposed to rupture than those of the anterior mesenteric artery. Of eighteen cases of known perforation, fifteen opened into the peritoneal cavity, and three into the bowel. The dangerous symptoms of the worm-aneurism are exclusively due to embolism and thrombosis of the affected artery, arising from the parietal clot. The latter becomes especially dangerous through its increasing size and the softening which often accompanies it. The absorption and shrinking of this parietal clot, be it organised or not, is materially assisted by the high pressure to which it is exposed.

12. The very marked symptoms of vascular obstruction—the sero-hæmorrhagic intestinal infarct—in embolism and thrombosis of the mesentric arteries are easily explained by paralysis of the muscular coat of the intestine, by the absence or paucity of valves in the portal vein, by the readiness with which meteorismus (or flatus) arises, especially in herbivora, and by the loose consistence of the intestinal walls or villi.

13. The occlusion of the intestinal arteries, especially that arising suddenly, always has for its result a partial or complete paralysis of the portion of bowel which they supply. The palsy of the intestine causes the forward movement of the intestinal contents to cease, a stoppage of the fæces, a hindrance to the discharge of fæces and gas, and also that exceedingly dangerous formation of gas (within the intestinal tract) which in the herbivora is so abnormal, both quantitatively and qualitatively.

14. In embolism and thrombosis of the mesenteric arteries the symptoms during life are entirely identical with those observed in the so-called colic of horses, as has been determined by numerous observations. The partial paralysis of the bowel, which is brought on by the embolism and thrombosis of the mesenteric arteries, forms in great part the chief and leading feature of the series of symptoms known as the "colic" of

horses. The palsy of the bowel which arises in this way may explain also the frequent ruptures of the digestive canal and the greater number of its changes in position. The latter are specially favored by the structure of the abdominal viscera in the horse.

15. The old changes which one finds in the peripheral branches of the anterior mesenteric artery, in the form of expired and partly absorbed embolic and thrombolic processes (pigmentation, arterial and venous thrombi), particularly in connection with those arteries which are seats of the aneurism, decisively prove that the large majority of colics resulting in recovery, so far as they do not depend upon known injuries, are caused by paralysis of the bowel from embolism and thrombosis. The sudden occurrence, course, and result of these kinds of colics also testify to their embolic origin.

16. The œdematous, inflammatory, and hæmorrhagic processes that one often finds described as the cause of death in colic, almost exclusively depend on thrombosis and embolism of the mesenteric arteries, the cases forming about 40 to 50 per cent. of all fatal colics.

17. The rapid course in fatal colics, as well as the preponderating symptoms of dyspnœa in cases of recovery, is finally due to the abnormal development of gas in the alimentary canal. In addition to the diminution of the respiratory surface by the lofty position of the diaphragm, a direct gas-poisoning (carbonic acid and sulphuretted hydrogen) probably contributes to the intensity of the symptoms and the rapid course by diffusion of the abnormally developed gas out of the intestinal canal into the blood.

18. The variety of the anatomical derangements caused by embolism and thrombosis of the intestinal arteries is faithfully mirrored by the variety of the clinical symptoms and the different degrees in the intensity and course of the colic.

19. Amongst every 100 horses afflicted with internal disease, 40 are ill with colic. Among any hundred deceased horses 40 have perished from colic, and among 100 colic patients 87 recover and 13 die. The figures prove that neither amongst the epizoötic nor sporadic diseases of horses is there any other affection which occurs so frequently, or claims anything like so many victims. Like the frequency of the worm-aneurism, the amount of disease and mortality increases with advancing age. The etiology of the colic of horses finds in the thrombosis and

embolism of the mesenteric arteries, with the consequent paralysis of the bowel, an all-sufficient explanation, whilst the causes of colic hitherto accepted were for the most part insufficient.

20. In a great number of cases the thrombus of the worm-aneurism is continued past the mouth of the anterior mesenteric artery, into the lumen of the aorta, and, as such, is the exclusive cause of the embolisms of the pelvic and crural arteries which bring about the intermittent hobblings (the author says "intermitterenden Hinken," not "Hahnentritten," the usual equivalent term for stringhalt). Considering the excessive frequency of the thrombus being continued into the aorta, it becomes highly probable that a great part of the diseases and lameness of the posterior extremities ("Hüft und Kreuzlähme, unsichtbarer Spath, &c.," which may be rendered "sciatic and hip or spinal lameness, obscure spavin, &c.") are due to occlusion of the arteries.

21. Owing to the fibrous thickening of the connective tissue of the root of the anterior mesenteric round the aneurism, and to the considerable size of the latter, disturbances of the innervation of the intestine, (as well as) hindrances to the passage of the chyle, and irregularities in the portal circulation may be created, which may well lie at the root of many chronic disturbances of digestion in horses.

22. Considering the great losses and heavy social disadvantages that are occasioned by the colic of horses to the horse-breeder, to agriculture, and to the general welfare, it is of the highest importance to discover means which should prevent the introduction of the embryos with the food, and, as a consequence, the migration of the palisade worms into the mesenteric arteries of the horse.

I wish it to be distinctly understood that the above summary is translated from Bollinger (*Die Kolik*; s. 257). Instructive cases have been recorded both at home and abroad. Prof. Varnell has remarked that "foals and yearlings suffer more from parasites in the paddocks than they do on adjoining farms where only a few animals are bred." This is explained by the relatively greater amount of egg-dispersion proceeding from the infected brood-mares. It is quite evident that the lives of many valuable animals are annually sacrificed by the neglect of hygienic arrangements. The palisade worm is chiefly destructive to young animals, and as Mr. Percivall has well remarked, these parasites are "commonly the cause of lingering and hidden

disease, terminating in death," without any suspicion on the part of the practitioner as to the nature of the malady. Instructive cases of this form of helminthiasis are given by Messrs Littler, Wyer, Harris, Meyrick, Litt, Percivall, Tindal, Walters, Brett, Aitken, Mead, Clancy, Baird, Mercer, Wright, Seaman, Hepburn, and others.

Second only in clinical importance is the little four-spined strongyle (*S. tetracanthus*). The sexes, often seen united, are nearly of equal size, the largest females reaching nearly ¾". They infest the cæcum and colon, and have been found in all varieties of the horse, ass, and mule. The worm occurs in immense numbers and is a true blood-sucker. Its presence occasions severe colic and other violent symptoms, often proving fatal to the bearer. As already announced, in connection with my account of the tapeworms of the horse, this little worm may produce a virulent epidemic (epizoöty). In the sexually-immature state the worm occupies the walls of the large intestine, where it gives rise to congestion, ecchymosis, inflammation, and the formation of pus deposits. The species is readily recognised by its bright red color, by the four conical spines surrounding the mouth, by the two neck-bristles, and by the long three-lobed hood of the male, the posterior three-cleft ray having a rudimentary or fourth branch attached to its outer edge. In some specimens sent to me by Mr Whitney, I found this supplementary process fully twice as long as Schneider has represented it.

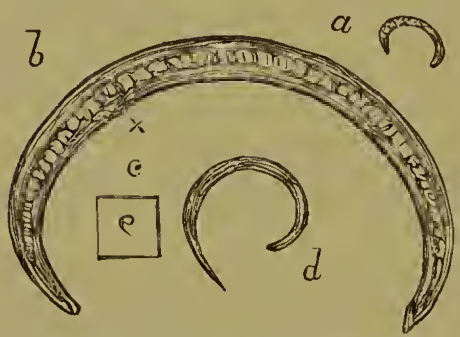

FIG. 63.—Larvæ of *Strongylus tetracanthus*. *a*, from the walls of the intestine (natural size); *b*, the same (enlarged); *x*, an injury; *c*, younger specimen (*in situ*); *d*, the same (enlarged). Original.

From the earliest times this entozoon has been confounded with the palisade worm. Rudolphi and several of his successors, and also in recent times Ercolani and Colin, regarded this worm as the progeny of *Strongylus armatus*. During my earlier examinations I likewise fell into the error of describing the immature worm as representing a new species. The parasites described by me as Trichonemes (*T. arcuata*) were identical with those which Prof. Dick had previously described as "worms at different stages of growth," in his MS. sent to Dr Knox, 1836. Parasites of this kind were described by Dr

Knox as "Animals similar to *Trichina;*" by Diesing as the "Nematoideum equi caballi;" by Mr. Littler as "Extremely small ascarides," in a letter to Mr Varnell; by Mr Varnell himself as "Entozoa in various stages of growth;" and by Prof. Williams as "Entozoa from the intestinal walls," in a letter to myself, dated March 13th, 1873. In reference, however, to Mr Varnell's account of Mr Littler's specimens I may observe that the appearances which he at first merely described as "blood spots," he afterwards characterised as dark points "containing young worms in various stages of growth."

As regards the course of development of this worm we have yet much to learn. Although the worm is a frequent cause of epizoöty in this country it appears to be but little known on the Continent. Krabbe makes no mention of the helminthiasis set up by the four-spined strongyle, but he points out that the young occupy the mucous membrane, in which situation they lie coiled so as to present to the naked eye the appearance of little dark spots (*Husdyrenes Indvoldsorme,* 1872, p. 17, 'Aftryk. af Tidsskr. for Vet.'). However, Leuckart's account of the appearances presented in a case brought under his notice is instructive. He writes :—"I have hitherto had only a single opportunity of examining the strongyle capsules in the intestinal membrane of the horse. Their presence is limited to the cæcum and colon, but they are so abundant in this situation that their numbers may be estimated by many hundreds. It was thus likewise in the case in question, the investigation of which by myself was rendered possible through the friendliness of Prof. Haubner of Dresden. The capsules were of oval form, and glimmered through the mucous membrane as opaque spots, mostly from one to three millimètres in size. In several of these capsules nothing was found beyond a greasy mass of a brownish color, which might readily be taken for a tuberculous substance; but the greater number of them contained a coiled worm, from three to six millimètres long, their breadth being 0·15 to 0·26 mm. (which is $\frac{1}{166}''$ to $\frac{1}{99}''$). They exhibited a highly colored stout intestine, and a thick-walled oral capsule of 0·022 mm. in depth and 0·025 mm. in breadth. On the dorsal side two three-cornered chitinous lamellæ arise from the shallow floor of the small oral capsule. The cuticle, notwithstanding its firm structure, was still destitute of annulations. The tail (0·15 to 0·18 mm. in length) was strongly marked off from the

rest of the body, being of a slender cylindrical form with a rounded-off extremity. The development of the sexual apparatus had not yet commenced. Notwithstanding the great differences of size presented by the body, the structure of all examples was exactly the same to the minutest particular, without exception. Also the smallest specimens, which scarcely measured one millimètre, found in capsules of 0·3 mm. in diameter, were distinguishable only by the absence of the oral cup, whose position was represented by a slender and thickened chitinous cylinder, as obtains in the earliest parasitic juvenile condition of *Dochmius trigonocephalus*. The transformation to the form presenting an oral cup occurs through a moulting, which is accomplished already in examples of 1·5 mm. in diameter. Later, also, the worms cast their skins in their capsules, without, however, changing the oral cup. In regard to the final purpose of this metamorphosis, my investigations have left me entirely in the lurch; nevertheless, I do not entertain the smallest doubt that the worms which I have here described are the larval forms of *Strongylus tetracanthus*."

From numerous examinations I have satisfied myself that the worms after escaping the walls of the intestine—and they may often be observed in the very act of passing—re-enter the lumen of the bowel to undergo another change of skin prior to acquiring the adult state. This they accomplish by rolling themselves within the fæcal matter of the horse's intestine. The best examples I have seen of this phenomenon occurred in a case for the clinical particulars of which I am indebted to Mr Cawthron. Most interesting was it to notice these immature worms, each coiled within a sort of cocoon, which Mr Cawthron termed a cyst. All the forty little cocoons more or less resembled pills, the bright red color of their contained worms strongly contrasting with the dark color of the cocoons. They consisted of compressed *débris*, which under the microscope showed many common forms of vegetable hairs and parenchyma, besides raphides and chlorophyll-granules. Internally, there was a cavity corresponding with the shape of the worm. In one instance I noticed that the worm had nearly completed

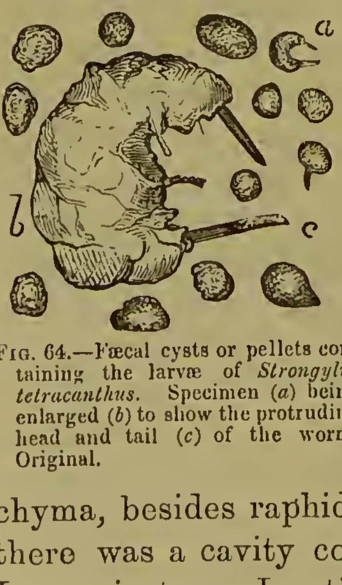

FIG. 64.—Fæcal cysts or pellets containing the larvæ of *Strongylus tetracanthus*. Specimen (*a*) being enlarged (*b*) to show the protruding head and tail (*c*) of the worm. Original.

its ecdysis, a portion of the old skin still remaining attached to the tail.

As already remarked, the evidence respecting the frequency and destructiveness of this little worm in England is now quite overwhelming. In a series of papers contributed to the 'Veterinarian' (too long for full quotation here), I have endeavoured to do justice to the "finds" and observations of those members of the veterinary profession who were good enough to supply me with valuable notes and communications. In particular must my indebtedness to Mr Rees Lloyd be acknowledged, for, as previously observed, he it was who first recognised the parasitic character of the Welsh epizoötic outbreaks. In the Deangunid and Talybont districts these strongyles proved terribly fatal to mountain ponies. It appears that the owners of the animals, as soon as they perceived anything amiss, at once disposed of them by sale, evidently anticipating fatal results sooner or later. The facts connected with some of the isolated cases brought under Mr Lloyd's care are especially interesting, as showing the virulence of the symptoms set up. Thus on the 9th of Feb., 1875, some time after I had identified the species from specimens he had sent me, Mr Lloyd writes as follows:—"The last case I had was one which had been sold in this way, and which had suffered now and then from colicky pains for the space of about two months. The animal had been drenched with febrifuges and rubbed with stimulating liniments about the throat. However, I was sent for one evening, about an hour before the patient's death. I soon diagnosed the case as parasitic, and at the same time considered it to be a hopeless one. I remained with it the whole of the time, of which about forty-five minutes of the most acute pain was borne by the trembling beast, which was leaping, rolling, and tossing itself about with astonishing rapidity. The bulging eyes, gnashing teeth, foaming mouth, and sharp peculiar hoarseness, were pitiable to behold; when suddenly all was silent, he quietly rose to his feet, and nipped the grass as if nought had troubled him. I then trotted him quietly up a few yards of rising ground in the corner of the field, when he immediately got down to rise no more. The next day I examined him, and found myriads of the four-spined strongyles, a large number being encysted." Mr Rees Lloyd's account of this case is so graphic that I have reproduced it without abridgment. Speaking of another patient, a mare, he says,

"she had voided thousands of these parasites, and was in a frightfully emaciated condition, but beyond a craving appetite there was little else to be noticed." Notwithstanding the few diagnostic indications afforded, Mr Lloyd, being led by the history of the case to suspect worms, at once examined the fæces, when he discovered thousands of these minute nematodes. Clinically, these facts ought not to be lost sight of. In addition to Mr Lloyd's cases I have received valuable particulars of others at the hands of Prof. Williams, Messrs Cawthron, A. Clarke, T. Gerrard, D. M. Storrar, and J. W. Whitney.

Practically, it is important to inform the persons most interested that an active "drench" may be serviceable in dislodging the free intestinal worms, but the administration of purgatives must not be persevered in. As in the somewhat parallel case of Trichinosis in the human subject, the fatality of the disorder depends not upon the free and mature worms, but upon the migrating and sexually-immature forms. All attempts by means of active drugs to poison the entozoa, when once they have gained access to the tissues (whether actually capsuled or not), are worse than useless. By all means let the animals have a dose of aloes in the first instance, followed by warm bran mashes ; but thereafter let every care be taken to support the patient's strength. Especially should the exhibition of turpentine be avoided. Without doubt the cause of this, as of other similar epidemics, is primarily referable to atmospheric conditions which favor the multiplication of parasites. As the practical man cannot alter these climatal changes, he must do his best to check the disorder by removing the victims to new localities ; or, if the animals must remain in infected districts, by supplying them with various kinds of artificially prepared fodder, supplemented by carefully filtered water. In this way, I believe, epidemics may be arrested, but they cannot be stamped out altogether, except by the adoption of measures which would be alike impracticable and unwarrantable.

Passing to the consideration of other intestinal nematodes, the next in importance is the large lumbricoid (*Ascaris megalocephala*) found in all solipeds, including the zebra. Whilst the male worms rarely exceed seven inches in length, the females sometimes reach seventeen inches. Science is indebted to Schneider for setting at rest all doubt as to the specific distinctness of this worm. The far larger number of caudal papillæ at once distinguishes it from the lumbricoid of man and the

hog. The equine Ascaris may occur in any part of the alimentary canal, but the small gut forms its proper head-quarters. The entire course of development of this worm has not been traced; nevertheless, Heller found human lumbricoids measuring less than the eighth of an inch. It is not likely that any intermediate host is necessary for the growth of the larvæ, prior to their access to the definitive host. I have reared the larvæ in impure water and in moist horse-dung, up to the size of $\frac{1}{30}$ of an inch. They were then furnished with a completely-formed digestive apparatus. Davaine kept the intra-chorional embryos alive in water for five or six years. His experiments on rats, dogs, and on a cow, led to no decisive results; but it is important to know that the eggs of lumbricoids effectually resist dryness. According to Davaine, however, embryonal development is thus arrested (except in *Ascaris tetraptera* of the mouse).

Seeing how readily the most ordinary attention to cleanliness must suffice to prevent lumbricoid helminthism, it is scandalous that so many severe cases of disease from this source should ever and anon turn up and be reported. In no properly conducted stable are these large entozoa ever to be seen in any considerable numbers; for so long as the water-supply is good and the fodder clean there is no possibility of infection. A fertile source of infection, however, results from allowing horses to drink at foul road-side ponds and from open waters in the vicinity of stables and paddocks where foals are reared. Into the clinical bearings of the subject I do not enter, but a host of interesting records of lumbricoid disease may be found in veterinary journals, both home and foreign. These have their counterpart in the very similar cases recorded in the medical journals, and quoted by me in the 34th bibliography of this work. From Sonsino's report these worms do not appear very common in Egypt, but the veterinary inspector, Dr Zunhinett, had occasionally met with them. From Messrs W. Awde, J. B. Wolstenholme, and other English veterinary surgeons, I have received notes of interesting cases, but in this connection I can only further refer to the published cases of Messrs Anderson, Boddington, Cartwright, Harrison, Moir, and Wallis. The French cases, by M. Cambron and by M. Véret, are particularly instructive. Many of the cases give fatal results. In one fatal instance a pupil of mine counted over 1200 of these worms, and in a similar fatal case Mr Lewis reports that

he found the small intestine literally crammed, some thousands of worms being huddled together in large masses.

The next nematode of general interest is the pinworm (*Oxyuris curvula*). Professional men often confound it with the palisade worm, and it has even been mistaken for the rat-tail maggot (*Helophilus*). The longest males measure $1\frac{3}{4}''$, and the females often beyond 4 inches. This worm infests the colon in great numbers, the species being easily recognised by its long subulate tail. Like its much smaller congener infesting man, this worm occasions severe local irritation, clusters of the eggs often accumulating to form yellow incrustations at the

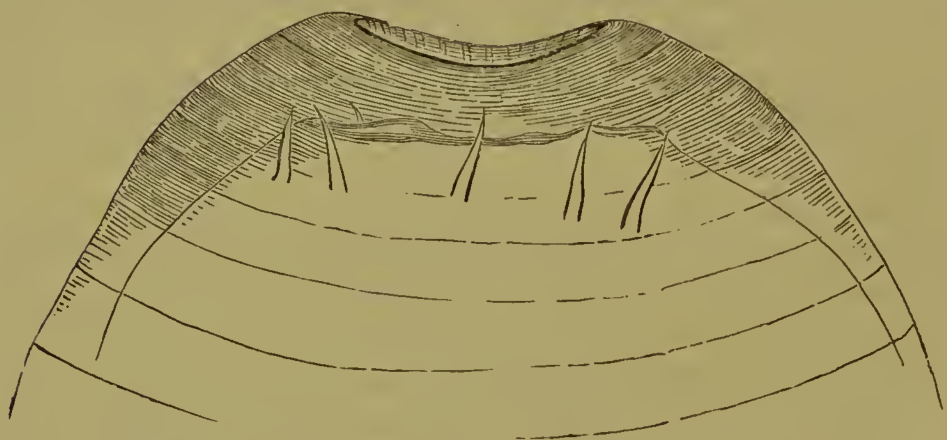

FIG. 65.—Head of *Oxyuris curvula*. Highly magnified. After Busk.

verge of the anus. Equine pinworms are vegetable feeders, and, like human Oxyurides, are conveyed to the bearer in a direct manner. No horse properly looked after can be infested by these worms. Local washings and stable cleanliness being secured by an attentive groom, the animals are safe. Prophylactic measures of this kind are all-powerful against infection. Notwithstanding the ease, however, with which the oxyuris disorder may both be prevented and cured, we find it prevails extensively everywhere, alike in mankind and in solipeds. Dr Sonsino found these parasites abundant in Egypt, some of the worms reaching a length of nearly five inches (120 mm.). Mr Emmerson has given an interesting account of the prejudicial effects of these entozoa in the horses of Singapore.

One of the most remarkable equine parasites is that which I am in the habit of calling the large-mouthed maw-worm (*Spiroptera megastoma*), in contra-distinction to the small-mouthed species (*S. microstoma*). In this country the worm has attracted little notice, but through the kindness of Mr Spooner

Hart, of Calcutta, and of Mr Percivall, of the 11th Hussars, stationed at Umballa, I have had abundant opportunities of examining this entozoon and the singular pathological appearances which it occasions. This parasite was first described by Rudolphi, who says:—" Spiroptera capitis discreti ore magno nudo, cauda feminæ rectiuscula acuta, mavis simpliciter spirali, corpusculis rotundis ad basim penis styliformis." The worm was afterwards observed by Schultze, Chabert, and frequently also by Andral, but the best accounts of it are those given by Gurlt, Valenciennes, and Dujardin. Schneider has likewise done much to set at rest disputed points. Respecting the *Spiroptère du Cheval*, Dujardin, writing in 1844, observes that " Rudolphi at first studied this helminth from examples found in great number by Reckleben, at Berlin, in tubercles of the stomach of two horses. Quite recently, M. Valenciennes, at Paris, has found it frequently in tumours, from twenty to forty millimètres in size, in the stomach of eleven horses out of twenty-five that he had subjected to this kind of research. These tumours, lodged between the mucous and muscular layers of the digestive canal, are perforated by several holes traversing the mucous membrane. They are divided internally by a number of folds into numerous intercommunicating cavities, and sometimes filled with solid mucus and very many spiropteras. It is from examples collected by M. Valenciennes that I have been able to study the parasite."

As regards the description of the worm, it is almost needless to say that Dujardin's account is minute and admirable in all respects. In fact, no naturalist ever exceeded the Rennes *savant* in carefulness and accuracy of detail. An interesting point connected with these stomach-worms lies in the circumstance that Gurlt recognised two varieties, one of which he termed *Sp. meg.*, var. *major*. It remained for Schneider to show that the larger worms formed an altogether distinct species, which he termed *Filaria microstoma* ('Monogr.,' l. c., 1866, s. 98). It was not unnatural that Rudolphi and his successors should confound these two forms together, and it is also not a little curious that the smaller of the two species has the larger mouth. Practically, veterinarians will probably rest content to know that whilst the *Spiroptera megastoma* occupies tumours in the walls of the stomach, the *S. microstoma* is always to be found free in the cavity of that organ. Any helminthologist who may chance to have read the Ceylon Company's report on the

fatal epidemic affecting the mules of the Mauritius in 1876 can scarcely fail to have observed that the worm called *Ascaris vermicularis* by Mr Bradshaw is none other than our *Sp. megastoma.* The description of the tumours as "reticulated" sufficiently explains their honeycomb-like appearance, but I think that the expression "alveolar" would better convey their true pathological character. Mr Spooner Hart compared these structures, which he terms "abodes," to mole-hills, but there is no good ground for supposing that the wanderings of the parasites are in any sense comparable to the burrowings of the mole. In like manner the expression "nidus," employed by Mr Bradshaw, though suggestive of their nest-like appearance, is to some extent misleading, as it implies that the worms form a nide or brood. Possibly, it may turn out that all the nematodes in each tumour have been bred in the spot where they are found, but hitherto they have only been seen in the adult state. Earlier stages of growth should be diligently sought for. Widely dissimilar as the two maw-worms are, it would not greatly surprise me to learn that *Sp. megastoma* and *S. microstoma* are dimorphic conditions of one and the same entozoon. At all events, Ercolani's determination of the relations subsisting between *Ascaris inflexa* and *A. vesicularis* suggests a possible analogy of this kind. I may mention that the male *Spiroptera megastoma* reaches nearly one third and the female one half of an inch in length. A constriction separates the head from the body. The mouth is surrounded by four thick horny lips, the dorso-ventral pair being the larger. The tail of the male is spirally twisted, and furnished with lateral bands supported by three or four ribs. It carries two curved spicules of unequal size. There are five pairs of caudal papillæ, the tail being bluntly pointed in both sexes. The vulva of the female is placed about $\frac{1}{7}''$ below the head. The eggs are linear or very narrow, and furnished with thick shells. According to Sonsino, who found *Sp. megastoma* in five out of sixteen Egyptian horses, the verminiferous growths are usually seated near the pyloric end of the stomach, as many as four tumours occurring at one time. Neither Sonsino nor any other observers already quoted appear to think that these morbid changes in any way interfere with the healthy performance of the gastric functions. However, I am of opinion that at least one recorded fatal case of parasitism, producing rupture of the stomach, affords an instance, however rare, of the injurious

action of this entozoon. It is reported under the signature of "Argus," quoted below.

In this connection I may mention that in 1864 Prof. Axe observed some small worms, scarcely visible to the naked eye, in the mucous membrane of the stomach of a donkey, the same worms being subsequently observed in three other donkeys brought to the dissecting room of the Royal Veterinary College. From the examination of a drawing of one of the male worms, executed by Prof. Simonds, I am led to believe that the parasites are entirely new to science. The hood being well marked there can be no doubt as to the strongyloid affinities of the worm. I therefore propose to call the worm after its discoverer (*Strongylus Axei*).

In regard to *Sp. microstoma*, the males measure up to $\frac{2}{3}''$, whilst the females have a long diameter of $\frac{3}{4}''$ or rather more ($10'''$). The small-mouthed maw-worm lives free in the stomach, and, as Krabbe observes, not unfrequently in very considerable numbers. It does not appear to be capable of injuring the host.

One of the most interesting equine nematodes is the eye-worm. Most veterinary writers speak of it as the *Filaria oculi*, but to helminthologists it is better known by the more correct designation, *F. papillosa*. Though commonly obtained from the eyeball and its tunics, the worm infests various tissues and organs of the body, being found in the thorax, abdomen, membranes of the brain, muscles, and cellular tissues. It infests the ass and mule, and also horned ruminants. The males attain a length of three inches and the females seven inches. The head is broad, with a gaping mouth armed with a ring of chitine and two prominent denticles. There are also two papillæ on the neck near the middle line, besides sixteen caudal papillæ, eight on either side. The tail of the male is spirally twisted, that of the female only slightly curved. Notwithstanding the many opportunities afforded of examining this parasite in the fresh state, very little is known respecting its origin and course of development. Dr Manson, who found that the mouth was armed with a five- or six-toothed oral saw, considers that the eye is not a proper resting place for the parasite, and that when one wandering worm comes across the track of another it follows it up from sexual instinct, and thus several may be found together in one place. The tracks are readily seen by the naked eye. Dr Sonsino speaks of it as a "yellow line." This Italian observer found the worm in twelve

out of the sixteen solipeds he examined during the plague. Each horse showed from two to a dozen worms "in the peritoneal cavity, wandering free on the serous lining, without causing any apparent mischief to the membrane." On one occasion Sonsino found the worm in the liver. From the similarity of habit there can be little doubt that the cases of guinea-worm (*F. medinensis*) recorded by Clarkson and others, as occurring in the horse, were merely examples of *F. papillosa.* I think so all the more because the lamented Fedschenko verbally expressed to me his astonishment that I had in my introductory treatise (p. 387) spoken of the Dracunculus as an equine parasite. I did so on the authority of others. To the Rev. Horace Waller I am indebted for specimens of the eye-worm brought from Assam, and to Mr Spooner Hart for others sent from India. For examples occurring in England I am indebted to Mr Haydon Leggett, who, in 1875, sent me three specimens extracted from the eye of a five-year-old mare. Mr Steel has also given me an example of *F. papillosa* taken from the peritoneum of a donkey. Similar cases are constantly occurring in the practice of veterinarians in Hindostan. Highly interesting Indian cases are recorded by Kennedy, Molyneux, Twining, and Breton, and in addition to these I may also particularise those of Macnamara, C. Percivall, Hickman, Clarkson, Skeavington, and Jeaffreson. The cases by Lee and Grellier also deserve attention.

Another species of thread-worm (*Filaria lacrymalis*) is occasionally found in the horse between the lids and eyeball. It is a comparatively small and harmless parasite, the males measuring $\frac{1}{2}''$ in length and the females $\frac{2}{3}''$. It also infests the ox. Both the large and small eye-worms are viviparous, and, not improbably, both of them are the means of conveying embryonic Filariæ into the circulation. Be this as it may, we owe to Dr Sonsino the discovery of hæmatozoa in an Egyptian horse. The larval worm was provisionally named by him *Filaria sanguinis equi.* The microscopic nematodes closely resemble the larvæ of *F. sanguinis hominis,* but they are smaller. The horse from whose blood Dr Sonsino obtained the minute worms was also found, by post-mortem examination, to have been infested by *Filaria papillosa,* a circumstance which naturally suggested a genetic relation between the larval and adult parasites. Similar, if not the same, microscopic worms had been previously discovered by Wedl, who primarily and independently regarded

them as embryos of *F. papillosa.* Another curious filaria-like entozoon is the reticulated threadworm (*Onchocerca reticulata*). In England we have no acquaintance with this singular parasite, but it appears to be tolerably common in Italy. Excellent figures of it have been given by Diesing. Both males and females are in the habit of coiling themselves within the muscles, where they are found invested by a capsule of connective tissue. When unrolled the sexes are found of equal size, acquiring a length of 1½″. The worm has a simple unarmed mouth, its body being marked by a series of annulations formed of incompletely anastomosing rings. It does not appear to possess any clinical importance.

In connection with the equine nematodes I need only mention the lung-worm (*Strongylus micrurus*). Its importance in relation to the production of husk or parasitic bronchitis in calves has already been considered. The worm is rarely productive of mischief amongst solipeds, nevertheless, in the dissecting-room subjects at the Royal Veterinary College, the presence of these parasites in the lungs is frequently noticed. Lastly, it only remains for me to observe that the renal strongyle (*S. gigas*) is occasionally seen in the horse. In 1792 M. Chabert found one in the left kidney, and similar cases have since either been witnessed or reported by Rudolphi and Leblanc.

Of the numerous insect parasites and tormentors of solipeds the gadflies (*Œstridæ*) demand chief attention. For special description of the forms, Brauer's monograph is the most, and, in fact, the only reliable authority. Here it is not possible to give the characters of the various equine species, of which at least half a dozen are known to science. As remarked by me in the special chapter contributed to Prof. Williams' well-known veterinary treatise, the common gad-fly (*Gastrophilus equi*) attacks the animal whilst grazing late in the summer, its object being, not to derive sustenance, but to deposit its eggs. This it accomplishes by means of a glutinous excretion, causing the ova to adhere to the hairs. The parts selected are chiefly those of the shoulder, base of the neck, and inner part of the fore legs, especially about the knees, for in these situations the horse will have no difficulty in reaching the ova with its tongue. When the animal licks those parts of the coat where the eggs have been placed, the moisture of the tongue, aided by warmth, hatches the ova, and in something less than three weeks from the time of the deposition of the eggs, the larvæ make their

escape. As maggots they are next transferred to the mouth, and ultimately to the stomach along with food and drink. A great many larvæ perish during this passive mode of immigration, some being dropped from the mouth, and others being crushed in the fodder during mastication. It has been calculated that out of the many hundreds of eggs deposited on a single horse, scarcely one out of fifty of the larvæ arrive within the stomach. Notwithstanding this waste the interior of the stomach may become completely covered with "bots." Whether there be few or many, they are anchored in this situation chiefly by means of two large cephalic hooks. After the bots have attained perfect growth they voluntarily loosen their hold, and allow themselves to be carried along the alimentary canal until they escape with the fæces. Many persons suppose that during their passage through the intestinal canal they re-attach themselves to the mucous membrane, thereby occasioning severe intestinal irritation. This is an error. In all cases they sooner or later fall to the ground, and when transferred to the soil they bury themselves beneath the surface, in order to undergo transformation into the pupa condition. Having remained in the earth for a period of six or seven weeks they finally emerge from their pupal-cocoons as perfect dipterous insects. It thus appears that bots ordinarily pass about eight months of their lifetime in the digestive organs of the horse.

That they are capable of giving rise to severe disease there can be no doubt, but it is not often that the disorder is correctly diagnosed, since it is only by the passage of the larvæ that the practitioner can be made aware of their presence. Mr J. S. Wood has published a case of tetanus in a mare, associated with the larvæ of *Œstrus equi*, and Mr J. T. Brewer has also given a case where the duodenum was perforated by bots. Mr Goodworth records an instance of pyloric obstruction from the same cause, and Mr W. Coupe informed me in 1876 that he had a drove of foreign ponies under his care, all of which suffered irritation from hæmorrhoidal bots. He removed them with a pair of forceps. Although frequently said to do so, the common bot does not attach itself to the rectum before finally escaping the host. The larvæ of *G. hæmorrhoidalis* normally reside there. In this situation they seriously inconvenience the bearer. The bots of *G. nasalis* are often confounded with those which ordinarily occupy the stomach of the bearer. The larvæ of *G. nasalis* commonly reside in the duodenum near the pylorus.

According to Schwab and Brauer, they rarely occupy the stomach. As occurs in the common species, this bot passes away with the fæces, and does not attach itself to the lower bowel. The bots of Brauer's *G. inermis* much resemble those of *G. equi*, but they are much smaller and attach themselves to the wall of the small intestine. The bots of *G. pecorum*, which dwell in the rectum, are readily recognised by their peculiar form and scanty spination. They are pointed in front and truncated posteriorly. An assinine variety of *G. equi* has been described by Bilharz, whilst another distinct species (*G. flavipes*) attacks the ass and mule. The bot-larvæ of the latter host require recognition and description. A great variety of other equine bot-flies have been described, but all, or nearly all, of them are mere synonyms of the above-mentioned forms. For the limitation of the species I accept Brauer's authority, and likewise his nomenclature. A great deal of nonsense has been written respecting bots. It is a relief to believe that *G.* (Œstrus) *veterinus*, *G. ferruginatus*, *G. jubarum*, *G.* (Œ.) *Clarkii*, *G. salutiferus*, *G. subjacens*, and many others, are not good species, at least that they are mere synonyms. In regard to the occurrence of subcutaneous bot-like maggots in the horse and ass, no doubt need exist on this point. I am indebted to Mr Percy Gregory for characteristic specimens taken from the back, neck, and withers of a four-year-old gelding. They appear to correspond with the *Hypoderma Loiseti* of Joly. Similar maggots have been found in the ass by Herr Erber, but Brauer refers these to *H. silenus*. Prof. Brückmüller published a case where the brain was infested by larvæ ; and Mr Shipley has sent me an example of *H. equi*, which he states he removed from the choroid plexus of the brain. In addition to the cases by Woods, Goodworth, and Brewer, already quoted, others have been published by Tyndal and Cartwright.

Amongst the numerous other parasitic dipterous larvæ one must notice the rat-tailed maggots (*Helophilus*). A genuine instance of this kind has been brought under my observation, but the example recorded by Professor Axe was spurious. Professor Simonds and myself saw this supposed maggot, which was merely a very stout and pregnant *Oxyuris curvula*. Another genuine case was published by Mr. Stanley. This is quoted by A. Numan in his essay on *Cœnurus*. I have previously mentioned my having received an Helophilus-larva that had passed from the human body. One of the most troublesome

external parasites is the so-called horse-tick or forest-fly (*Hippobosca equina*). They attack the abdomen, flanks, and inner part of the thighs in great numbers, occasioning great distress to the bearer. Being of leathery toughness their bodies are not easily crushed, and they are removed only with great difficulty. There is an equine disease in Sweden called *Stackra*, which is erroneously attributed to injuries produced by a species of fly-maggot (*Lixus*) which lives on the fine-leaved water-drop wort (*Phellandrium*). As regards the so-called free parasites, or rather non-parasitic obnoxious insects, which torment solipeds, it is impossible even to enumerate them. The tsetse of South Africa (*Glossina morsitans*) is terribly fatal to the horse, but it is said that the mule, ass, and zebra do not suffer from its bites—an immunity shared by swine, goats, antelopes, and man himself. Major Vardon's rash experiment (based on the supposition that horses deprived of fresh green food would not suffer from the attacks of the fly) proved fatal to an animal which he purposely exposed on a much infested hill-top. The horse died ten days after it was bitten. According to Chapman, the bites of four tsetse flies are sufficient to kill an ox, but in man the irritation produced is very slight. Amongst other insects proving troublesome to solipeds may be mentioned the leg-sticker (*Stomoxys calcitrans*), the clegg (*Hæmatopota pluvialis*) which is very abundant in the West Highlands, various species of *Tabanidæ* and *Asilidæ* (*Tabanus autumnalis, T. bovinus, Chrysops cæcutiens, Asilus crabroniformis*), and also a host of ordinary flies and gnats (*Muscidæ* and *Tipulidæ*), as, for example, *Anthomyia meteorica* and *Culex equinus*. In India the bite of a species of *Simulia* gives rise to the formation of open sores of the most intractable character. As regards hemipterous insects it may be said that many species of lice (*Anoplura*) produce what is called phthiriasis or lousiness in the horse, some of them being derived from poultry. The best known species are *Trichodectes equi, T. scalaris, Hæmatopinus equi, H. vituli, H. eurysternus*, and the ass-louse (*H. asini*). Of the half dozen or more species infesting the hen (belonging to the genera *Goniocotes, Liotheum*, &c.) it is not probable that more than one or, at most, two of them are concerned in the production of poultry-lousiness in the horse. As an equine disorder this kind of phthiriasis was first described by Bouley. Cases in England have been observed by Messrs. Henderson, Moore, and Woodger. For some

account of cases of lousiness due to *Hæmatopinus* I am indebted to Mr S. Butters. As regards the scab, itch, and mange insects or mites (*Acaridæ*), three perfectly distinct forms are known. Adopting M. Mégnin's classification they are *Scarcoptes scabiei*, var. *equi*, *Psoroptes longirostris*, var. *equi* (being the *Dermatodectes equi* of Gerlach), and *Chorioptes spathiferus*, var. *equi*, which is the *Symbiotes equi* of Gerlach. All the species have been beautifully illustrated by M. Mégnin, whose memoir has dispersed many of the clouds of error and misrepresentation which have hitherto surrounded the subject. Whilst *Psoroptes* forms the true horse-mite, and attacks various parts of the body, *Chorioptes* confines its attacks to the posterior regions. Messrs South and Day and myself have verified some of the facts recorded by Mégnin in respect of the structure and habits of this last species. Another kind of mite (*Glyciphagus hippopodos*) is stated to infest the ulcerated feet of horses. It would appear that no true ticks properly belong to solipeds ; nevertheless, the common cattle-tick (*Ixodes bovis*) occasionally attacks horses. Probably several other species of Ixodidæ, known to infest other animals, behave in the same way. The Arachnidan called *Pentastoma tænioides*, though properly belonging to the dog, has on several occasions been detected in the nasal or frontal sinuses of the horse. Such instances are recorded by Chabert and Greve. The largest example of this singular entozoon seen by myself was obtained from the same situation, and presented to me by the late Mr C. B. Rose, whose writings I have frequently quoted in connection with the *Cœnuri* of rabbits.

Bibliography (No. 50).—*Aitken, J.*, "Worms in the Spermatic Artery of a Colt," 'Veterinarian,' p. 683, 1855.—*Anderson, J.*, "A Case of Strangulation of the Ileum (with Lumbrici)," 'Veterinarian,' p. 261, 1859.—(Anonymous), "Rupture of the Stomach, associated with the existence of Cysts between its Coats containing Worms," 'Veterinarian,' March, 1864, p. 151. —(Anon.), "Extraction of *Filaria oculi* from the Horse," by "Miles," 'Veterinarian,' 1864, p. 218.—(Anon.), "Case of *F. oculi* in the Horse," 'Veterinarian,' 1864, p. 218.—(Anon.), "Worms in the Coats of the Stomach of a Horse," by "Argus," in the 'Veterinarian,' 1865, p. 151.—*Baird, W.*, "Notice of *Sclerostoma* in the Testicle of the Horse," 'Proc. Zool. Soc.,' 1861.—*Blanchard*, "*Anoplocephala perfoliata*," 'Ann. des Sci. Nat.,' 3rd ser., tom. x, p. 345.—*Bollinger, O.*, 'Die Kolik der

Pferde und das Wurmaneurisma der Eingeweidearterien,' Munchen, 1870. (Reviewed by myself in the 'Veterinarian,' Jan.–April, 1874.)—*Bovett*, "Existence of Filariæ in a Sinuous Ulcer of the Withers of a Mare," 'Veterinarian,' p. 515, 1861.—*Bradshaw, C.*, "Death of Mules from Parasitic Disease in the Mauritius (with remarks by Dr Cobbold)," 'Veterinarian,' Dec., 1876, p. 837.—*Brauer, F.*, 'Monographie der Œstriden,' Wien, 1863.—*Idem*, "*Œstr.* (*Hypoderma*) *Clarkii*," in 'Verhandl. der zool.-bot. Gessellsch. in Wien,' xxv, p. 75.—*Idem*, "On *Cephenomyia trompe* from the Reindeer," *ibid.*, p. 77.—*Idem*, "*Hypoderma bonassi* from the American Buffalo," *ibid.* (all with figs.), 1875.—*Breton*, "On the Worm found in the Eye of the Horse," 'Calcutta Med. and Phys. Soc. Trans.,' vol. i, 1825, p. 337.—*Brown, D. S.*, "The *Œstrus equi*, or Horse-bot," the 'Veterinary Journal,' July, 1877, p. 14.—*Brückmüller*, "Larvæ in the Brain of a Foal," from 'Viert. für wissensch. Vet.,' in 'Veterinarian,' p. 82, 1857.—*Cartwright, W. A.*, "On Strangulation of the Bowels, associated with about 150 Bots, and also some 150 Ascarides, in the Horse," 'Veterinarian,' p. 413, 1833.—*Idem*, "Case of about 200 'Bots in the Œsophagus' of a Horse," *ibid.*, p. 400, 1828.—*Chambron*, "On a Parasitic Malady in the Horse," from 'Ann. de Méd. Vét.,' in 'Edin. Vet. Rev.,' 1861; see also (*Cambron*) 'Veterinarian,' 1860, p. 612.—*Clark, B.*, "Obs. on the genus Œstrus," 'Linn. Trans.,' vol. iii, p. 289, 1797.—*Idem*, 'An Essay on the Bots of Horses and other Animals,' London, 1815.—*Clarkson, N. F.*, "Case of *Filaria oculi* in the Horse," 'Vet. Rec.,' vol. i, p. 73, 1845.—*Idem*, "Case of *Filaria medinensis* in the Horse," *ibid.*, 1845.—*Cobbold*, "On the Diptera (bots)," in a chap. on the Parasitic Diseases of Animals, in Williams' work (l. c., Bibl. No. 48).—*Idem*, "Obs. on rare Parasites from the Horse," 'Veterinarian,' Feb., 1874.—*Idem*, "Further remarks on rare Parasites from the Horse," *ibid.*, April, 1874.—*Idem*, "Fatal Epid. affecting Ponies," *ibid.*, June, 1874.—*Idem*, "Remarks on Mégnin's Tapeworm," *ibid.*, Sept., 1874.—*Idem*, "Report on Parasites (sent from India by F. F. Collins and Spooner Hart)," *ibid.*, Nov., 1874.—*Idem*, "Epizoöty in the Horse, more especially in relation to the Ravages produced by the Four-spined Strongyle (*S. tetracanthus*)," *ibid.*, April, 1875.—*Idem*, "The Egyptian Horse Plague in relation to the question of Parasitism," *ibid.*, Nov., 1876.—*Idem*, "Description of the new Equine Fluke (*Gastrodiscus Sonsinoii*)," *ibid.*, April, 1877.—*Idem*, "On

Worm-like Organisms within the Mitral Valve of a Horse," *ibid.*, 1877.—*Idem*, "Entozoa of the Horse and Elephant" (see Bibl. No. 51).—*Idem*, "Observations respecting the Large-mouthed Maw-worm of the Horse," 'Veterinarian,' Jan., 1877. —*Couchman, T.*, "Worms in the Kidney of a Colt," 'Veterinarian,' p. 145, 1857.—*Coupe, W.*, "Fatal Parasitism in a Colt," 'Veterinarian,' Dec., 1876, p. 844.—*Davaine*, "Les Cestoides," in 'Dict. Encycl. des Sci. Méd.,' p. 591.—*Dick* (see Knox).—*Dickens, C.*, 'Joint-lameness in Colts, associated with and symptomatic of Lumbricoid Worms," 'Veterinarian,' p. 601, 1863.—*Dun, R.*, "Remarks on Entozoa of the Horse," 'Veterinarian,' 1854, p. 445.—*Dupuy* (with M. Prince), "Filariæ in the Great Mesenteric of a Horse," 'Veterinarian,' 1835, p. 570. —*Emmerson, C.*, "Prevalence of Entozoa among Horses in the Island of Singapore," 'Veterinarian,' 1861, p. 514.—*Friedberger, F.*, 'Die Kolik der Pferde,' Berlin, 1874. (Reviewed by me in the 'Veterinarian,' Jan.—April, 1874.)—*Fry*, "Case of Worms in the Horse," 'The Hippiatrist,' &c., vol. iii, p. 10, 1830.—*Gamgee, J.* (senior), "On Bots," 'Edin. Vet. Rev.,' July, 1858. —*Goodworth, S.*, "Obstruction of the Pyloric Orifice of the Stomach by Bots," 'Veterinarian,' p. 410, 1837.—*Grellier, J.*, "On the Worm in the Eye (of the Horse)," 'Veterinarian,' p. 18, 1844.—*Harlan, R.*, "Case of a Colt killed by Worms," in his 'Med. and Phys. Researches,' p. 554; see also 'Med.-Chir. Rev.,' 1836.—*Harris*, "A Case of Worms in the Arteries of a Colt," 'Veterinarian,' p. 307, 1834.—*Harrison, J. D.*, "The singular effect of Worms in the Stomach of a Mare," 'Veterinarian,' p. 331, 1842.—*Hickman, T.*, "Worm in the Eye of the Horse," 'Edin. Vet. Rev.,' 1864, p. 653.—*Hopkinson, F.*, "Account of a Worm in the Horse's Eye," from 'Trans. of Amer. Phil. Soc.,' in 'Med. Comment.,' vol. xi, p. 166, 1784.—*Hutchinson, J.*, "Hydatid in the Eye of a Horse," 'Path. Soc. Trans.,' and rep. in 'Lancet,' 1857.—*Huxley*, "On Echinococcus (from the Zebra)," see Bibl. No. 20, *o*.—*Jeaffreson, W.*, "Case of Removal of a Worm from the Eye of an Arab Horse," 'Lancet,' p. 690, 1836-37, and 'Veterinarian,' p. 471, 1837.—*Kennedy, M.*, "Account of a Nondescript Worm (*Ascaris pellucidus*) found in the Eyes of Horses in India," 'Trans. Roy. Soc. Edin.,' vol. xi, p. 107, 1816.—*Kirkman*, 'Hydatids' (see Bibl. No. 20, *o*).—*Knox*, 'Edin. Med. and Surg. Journ.,' 1836. —*Krabbe* (l. c., in text).—*Lee, C. A.*, "On *Filaria papillosa* in the Anterior Chamber of the Eye of a Horse (and on Filariæ in

general, &c.)," 'Amer. Journ. Sci. and Art.,' vol. xxxix, p. 278, 1840.—*Lessona, G.*, "On the Bot (or Œstrus) of the Horse," from 'Recueil de Méd. Vét.,' in 'Veterinarian,' p. 156, 1854. —*Leuckart* (l. c., in text).—*Litt, W.*, "A Singular Case (of an immense number of Worms in a Colt)," 'Veterinarian,' p. 529, 1852.—*Macnamara*, "On *F. papillosa* in the Eye of Man and the Horse," 'Indian Ann. Med. Sci.,' 1864.—*Marcet* (see Bibl. No. 34).—*Mead, J.*, "A Worm in the Scrotum of a Colt," 'Veterinarian,' 1843, p. 648.—*Mégnin*, "Petit *Tænia inerme* du Cheval," in 'Bull. de la Soc. Cent. de Méd. Vét.,' t. vi, 3e série, p. 112.—*Idem*, 'Monog. de la tribu des Sarcoptides,' &c.; see also review by myself in the 'Veterinarian,' Aug., 1877.—*Mercer, J.*, "On Entozoal or Worm-aneurism," 'Lond. Med. Gaz.,' 1847, and in part x of "Contrib. to Zool. Path.," in the 'Veterinarian,' p. 33, 1846.—*Meyrick, J.*, "Death of a Colt from Entozoa within the Abdomen," 'Veterinarian,' 1859, p. 695.—*Moir, J.*, "Rupture of the Ileum resulting from Worms," 'Veterinarian,' 1857, p. 265.—*Molyneux, R.*, "On Worm in the Eye of Horses in India," 'Veterinarian,' 1828, p. 309.—*Morgan, A.*, "Case of Hydatid in the Brain of a Mare," 'Veterinarian,' p. 396, 1855. —*Numan, A.*, 'Ueber die Bremsen Larven, im Magen der Pferde,' 1837.—*Idem*, "Entozoon (*Monostoma settenii*) from the Eye of a Horse," from 'Tidschr. voor naturl. Geschied. en Physiol.,' 1842, in 'Med.-Chir. Rev.,' 1842.—*Idem* (for remarks on *Cysticercus fistularis*), 'Over den veelkop blaasworm' (l. c., Bibl. No. 49), p. 263.—*Peall, T.*, "A Discourse on 'Worms,'" at p. 37, in his 'Observations, chiefly practical, on some of the more common Diseases of the Horse,' pub. at Cork, 1814.—*Percivall, C.*, "Worm in the Eye of the Horse (two cases)," 'Veterinarian,' p. 75, 1828.—*Percivall, J.*, "A Case of Ascarides in the large Intestines of the Horse," 'Veterinarian,' p. 358, 1829.—*Poulton, T. J.*, "Large numbers of Parasites in the Intestines of a Mare," 'Veterinarian,' 1866, p. 385.—*Seaman, J.*, "Worms in the Blood-vessels of Horses and Colts," 'Edin. Vet. Rev.,' 1864, p. 520.—*Simonds*, "On Disease of the Mesenteric Artery, produced by Strongyli," 'Path. Soc. Trans.,' 1854.—*Skeavington, G.*, "On Worm in the Eye of the Horse (three cases)," 'Veterinarian,' 1834, p. 196.—*Sonsino, P.*, "On the Entozoa of the Horse in relation to the late Egyptian Equine Plague," 'Veterinarian,' Feb. and March, 1877.—*Tyndal, J.*, "Worms in the Intestines of a Mare," 'Veterinarian,' 1843, p. 629.—*Twining, W.*, "Obs. on the Filaria or Threadworm

found in the Eyes of Horses in India," 'Calcutta Med. and Phys. Soc. Trans.,' vol. i, p. 345, 1825; rep. in 'Veterinarian,' p. 114, 1828.—*Valenciennes*, "On the *Spiroptera megastoma* of Gurlt," abstract of a paper from Acad. Sci. of Paris, reported in 'Lancet,' 1843.—*Varnell*, "Remarks on Cases of Parasitic Disease in Horses," 'Veterinarian,' p. 201, 1864.—*Veret*, "Perforation of the small Intestines by *Ascarides lumbricoides* (in the Horse)," from 'Rec. de Méd. Vét.,' in 'Veterinarian,' p. 569, 1837.—*Vincent*, "Curious case of Incurable Lameness from Hydatids," 'Veterinarian,' 1848, p. 674; see also p. 3, *ibid.*—*Wallis*, "Note on the occurrence of (250) Lumbrici in a Horse," 'Veterinary Record,' 1849, p. 300.—*Walters, R. G.*, "Parasites in the Kidneys of a Mare," 'Veterinarian,' 1866, p. 265.—*Woodger*, "Hydatid in the Brain of a Horse," 'Veterinarian,' 1863, p. 75.—*Woods, J. S.*, "Tetanus in a Mare, associated with the Larvæ of *Œstrus equi* within the Stomach and Duodenum," 'Veterinarian,' 1859, p. 693.—*Wright*, "Strongyli in the Scrotum of a Colt," 'Veterinary Record,' 1849, p. 385.—*Youatt*, "Worms between the Tunics of the Stomach," 'Veterinarian,' 1835, p. 571.—*Idem*, "Tetanus, Worms in the Trachea, and Dilatation of the Heart, in a Zebra," *ibid.*, p. 504, 1836.——*Idem*, "Worms in the Nasal Cavity of the Horse," *ibid.*, p. 329, 1832.—*Zangger*, "Remarks on Entozoa," from the French, 'Veterinarian,' 1855, p. 463.

Part X (Pachydermata)

Concerning the parasites and parasitic diseases of this miscellaneous assemblage of large mammals, I shall first speak of those of the proboscideans (Elephantidæ). Except by myself, they have been but little studied, and I am yet waiting for an opportunity to give further time to their consideration. When Diesing published his 'Systema' only two helminths were referred to the Indian elephant, namely, *Ascaris lonchoptera* and an undescribed fluke supposed to be a distome. The whole subject requires revision, but I think the following species must, for the present at least, be allowed recognition:—*Fasciola Jacksoni* (mihi), *Amphistoma Hawkesii* (mihi), *Ascaris lonchoptera* (Diesing), *Sclerostoma spinuliferum* (Baird), and *Dochmius Sangeri* (mihi). Either the *Ascaris* or the *Sclerostoma* is probably identical with Rudolphi's *Strongylus elephantis*.

At the Norwich Meeting of the British Association, in 1868,

I exhibited two flukes received from J. S. Thacker, V.S., of the Madras Army. They were handed to me by the late Dr Baird, and were labelled "Distoma taken from liver of elephant and forwarded for classification." I stated at the time that these entozoa were identical with certain flukes previously obtained from the duodenum and biliary ducts of an Indian elephant, and which, though carefully preserved in the Boston Museum, U.S., had never been properly described. They were only briefly noticed by Dr Jackson in his 'Descriptive Catalogue' of the Museum. In the summer of 1868 fifteen specimens of fluke, removed from Burmese elephants, had been forwarded to and received by Professor Huxley from Rangoon, accompanied by a statement to the effect that they were the cause of an extensive and fatal disease in Burmah. Through the kindness of Prof. Huxley I was allowed to make use of his specimens for the purpose of comparison and identification, and thus it became evident that our specimens were of the same species. It was also evident that the species could be none other than that represented by the Boston specimens. Further examination having made it clear that the organisation of these flukes departed from the ordinary distome type, I named the parasite *Fasciola Jacksoni*, at the same time offering the following description ('Entozoa,' Supp., 1869, p. 80) :—Body armed throughout with minute spines, orbicular, usually folded at either end towards the ventral aspect, thus presenting a concavo-convex form; oral sucker terminal, with reproductive papillæ about midway between it and the ventral acetabulum; intromittent organ $\frac{1}{4}''$ in length; digestive apparatus with two main zigzag-shaped canals, giving off alternating branches at the angles thus formed, the ultimate cæcal ramifications occupying the whole extent of the body; length, when unrolled, from $\frac{1}{2}''$ to $\frac{5}{8}''$, breadth $\frac{1}{3}''$ to $\frac{1}{2}''$." Now, if reference be made to the appendix of the late C. M. Diesing's 'Systema Helminthum,' it will be found that Jackson's statement had not escaped that helminthologist's notice, though, not having seen any specimens, he was not unnaturally led to place the species amongst the distomes proper. In Diesing's subsequently published 'Revision der Myzelminthen,' the species is formally characterised as the *Distomum elephantis* of Jackson ('Sitzungsberichte d. Math.-nat. Cl. d. k. Akad. d. Wissenchaften,' Bd. xxxii, 1858). In my "Synopsis of the Distomidæ," which appeared in the 'Journal of the Linnean Society' for 1861, I had also placed it amongst the distomes, not considering it

to be a doubtful form ('Proceed. Linn. Soc.,' "Zoology," vol. v, p. 9). These references exhausted the literature of the subject up to the time of the issue of my 'Manual' in 1873, where this fluke is again briefly noticed (p. 13). Several of Prof. Huxley's specimens have been added to the entozoological department of the Hunterian Museum. It is clear that all these notices and descriptions point to the same parasite. The worm has since been more carefully described by Dr R. H. Fitz, from a series of dissections and preparations made by Dr H. P. Quincy, and deposited in the Warren Museum, Boston, U.S.

About the middle of June, 1875, I received a letter from General Hawkes, of the Madras Staff Corps, dated Secunderabad, May 12th, 1875, and in reference to the subject before us he writes as follows :—" My attention has been recently directed to a very unusual mortality of elephants at this station. Out of twenty-eight elephants under my charge, no less than twelve have died within the last sixteen months, whereas the average annual mortality has been hitherto only two per annum out of thirty-eight in our establishment. In every case of death there appeared to exist serious organic disease quite sufficient to account for such death, but as the mortality increased I had a post-mortem examination made in each case; and although here also organic disease sufficient to account for death was present in each case, yet in every one of these elephants we found the liver-fluke in greater or less abundance." General Hawkes adds :—" Meanwhile I have sent you a small box containing three bottles, one containing the liver-fluke (*Fasciola Jacksoni*) referred to in your work on the parasites of domesticated animals. It seems possible that the other two species of parasites may not have been brought to your notice. Both of these, namely, the " masuri " and the " soorti," are very common in elephants. They are both found in the intestines only. The " masuri," when present in any quantity, cause considerable disturbance, and the animal instinctively resorts to the *eating of earth*, which it consumes in large quantities until the bowels are acted on and the worm expelled. The soorti is more common than masuri, and does not seem to inconvenience the animal very much. When expelled from the animal the soorti is a round white worm, like most of the threadworms ; the masuri, on the other hand, is of a delicate flesh color." Shortly after the receipt of this letter I obtained the entozoa in a good state of preservation. Accordingly I wrote to General

Hawkes, stating that the flukes were clearly referable to *Fasciola Jacksoni;* that the parasites to which the natives of Hindostan apply the term "soorti" were evidently examples of *Ascaris lonchoptera* (Diesing), previously called strongyles by Rudolphi; and that the worms which he called "masuri" were trematodes new to science. I named the species *Amphistoma Hawkesii,* in honor of the donor. The bottle contained as many as forty-nine specimens. I may here remark that I have made inquiries of the keepers of the elephants at the Zoological Gardens as to whether they have ever seen entozoa that were passed by the animals under their care. They replied in the negative, the keeper of the African elephants (Scott) having made frequent inspection of the fæces. I was the more anxious to secure information on this point since, during my frequent visits to the menagerie, I had observed that the African elephants were in the habit of swallowing large quantities of mud and dirt from small hollows in the ground near the great water-tanks in which they bathe. Prof. Garrod (who had dissected three elephants) also assures me that there has been no trace of an entozoon in any of the Indian elephants examined by him. In one dissected at Edinburgh the same negative result was obtained. From the facts at present in my possession, I conclude that the habit of earth-eating, displayed alike by Indian and African elephants (and, as stated in my account of the equine parasites, shared by horses), is not necessarily due to the presence of parasites. I apprehend rather, that it is resorted to by these animals under any circumstances of intestinal irritation, whether created by entozoa or other foreign agents. The notion of the elephant's intelligent self-cure by eating earth is a very old fable. Captain Forsyth, as quoted by Mr Fleming, alludes to it in his 'Highlands of Central India,' and I find the same ideas recorded by Williamson and Howitt. Forsyth says:—"Elephants are very liable to intestinal worms. They generally cure themselves by swallowing from ten to twenty pounds of earth." Captain Williamson says:—"They are much troubled with worms, for the cure of which the elephant eats earth. If the dung be inspected there will be seen an amazing number of moving objects, which much resemble pieces of chewed sugar-cane." Some excellent practical remarks are added, testifying to the value of the native remedy called *Kallah-nimok,* or *bit-noben,* which is a saline purgative. In Lieut. Ouchterlony's essay (quoted below) no allusion is made to the subject of worms.

General Hawkes afterwards supplied me with further information. In a letter from Secunderabad, dated July 30th, 1875, he says:—"As regards the liver-fluke (*F. Jacksoni*), it appears from your treatise to have been first observed in 1847. The only other published notice that I have been able to find of it is contained in a letter to a newspaper, dated 'Rangoon, 16th July, 1867,' and is signed 'R. B.' In this letter the unusual mortality of seven elephants in about fifteen days is attributed to the presence of this liver-fluke, the two other parasites (*Amphistoma* and *Ascaris lonchoptera*) being also present in the intestines." "Now (continues General Hawkes), in every case at which I was present *flukes were found in greater or less numbers* in the gall-ducts of the liver, and the *Amphistoma* was also as constantly present in the intestines, the soorti (*Ascaris lonchoptera*), contrary to the general experience of the elephant attendants, being less frequently met with, though from its color and slender shape it is not so easily detected among the huge mass of fæces as the larger *Amphistoma*." Speaking of the amphistoma General Hawkes says:—"This internal parasite is well known to all who possess elephants. It is alluded to by Dr Gilchrist in his treatise on the 'Diseases of Elephants,' first published in 1841, but he merely mentioned it under its local name, *masuri*, and made no attempt either to describe it scientifically or to ascertain its place in the natural system. As far as my experience goes it is only found in the intestines. These parasites appear to be very generally present in the elephant. When their numbers are few the 'host' is probably not much inconvenienced, but when present in any great quantity they undoubtedly cause much irritation. When this is felt, the animal, as before remarked, instinctively resorts to a simple and effectual remedy. He eats a quantity of earth, which purges him thoroughly and expels the amphistoma. The mahawats are of opinion that whilst the elephant is eating earth to relieve himself of the pests the daily allowance of rice should be scrupulously withheld; and they say that if the rice, which is given uncooked, is eaten by the animal under these circumstances, excessive purgation is induced, which frequently results in death. How far this opinion is founded on fact I am unable to say, but the mahawat's name for this disease means 'fasting,' and bears testimony to the generally received notion of the necessity of withholding the rice when the animal is eating earth."

When describing the parasites of the horse (p. 358), I spoke of Collins' amphistome from that animal, but in the letter addressed to me from Simla, 22nd March, 1875, Mr. Collins made no allusion to the earth-eating habit. He wrote :—"I forward you by this mail parasites found in the colon of a horse that died, a subject of fever peculiar to this country. There were *about a thousand* of the parasites, and nearly the whole of them were situated close to the cæcum, and were loose in the gut. Not having seen parasites at all similar to these, I have forwarded them for identification. They were of a brick-red color when first obtained." These explicit statements by Mr Collins are interesting from many points of view. One has only to place his specimens side by side with those from the elephant in order to satisfy one's self that the two forms are distinct. For the reasons already stated I provisionally called the worm *Amphistoma Collinsii*. It is probable that other veterinary surgeons have encountered this entozoon in India; but, unless they can point to some published account of the fact, Mr Collins is entitled to be considered as its discoverer. Doubtless many other European residents in India, Ceylon, and Burmah, must, like Dr Gilchrist, be well acquainted with the *masuri* as such, though unaware of their zoological position.

In a record of the post-mortem examination of one of the victims of the Secunderabad epizoöty, the veterinary surgeon said :—"No doubt disease of the lungs and subacute inflammation of the bowels were the immediate cause of death, but the large number of flukes in the liver and the intestinal parasites (*i. e.* the amphistomes) account in a great measure for some of the symptoms shown, and these symptoms accord in many respects with those shown in elephants that died in Burmah during the epizoöty (rot) in 1867, as recorded by R. B., notably, refusal of food, standing with mouth open, restlessness, and puffiness about the head and shoulders. The liver parasite is no doubt the same referred to by R. B., and is that termed by Dr Cobbold *Fasciola Jacksoni*." In reference to a later case the same officer remarks :—"I carried out the post-mortem examination with special reference to inquiry as to the probability of the mortality amongst elephants at this station being of parasitic origin. This was suggested to me by the former case. The post-mortem appearances differed in every respect. There were flukes in the liver, but in no great quantity, and the structure of the liver was sound. Although

not assisted by this case in attributing the mortality to parasitic origin, I am strengthened in my opinion that the death of the previous elephant was due to disease caused by the presence of the liver fluke." This report, by Mr W. S. Adams, is to some extent in harmony with later information. An epizoötic outbreak amongst elephants has occurred in England, at Sanger's Circus, and I had opportunity to examine one of the dead animals. In my own opinion, and in that of Mr F. Smith, the veterinary surgeon who attended the animals professionally, the disease was due to parasites. I obtained large quantities of *Amphistoma Hawkesii* from the intestinal canal, and also other worms. The death of one of the elephants was made the subject of litigation, when, as might be expected, great diversity of opinion as to the cause of the fatal issue prevailed.

Mr Smith, an old pupil of mine, regarding the amphistomes and strongyles as the cause of death, wrote to the effect that "some of the worms were found between the coats of the intestine, and others on the free surface of the gut, whilst the excretory ducts of some of the glands were found blocked with them." The animal examined by myself on the 24th of August, 1876, yielded numerous examples of *Amphistoma Hawkesii*, *Ascaris lonchoptera*, and *Dochmius Sangeri*, the last species being so named by me after the owner of the circus who lost the herd of elephants by the epizoöty. The male *Dochmii* measured $\frac{5}{8}$ and the females $\frac{3}{4}$ of an inch in length. Here I must reluctantly quit the helminths of elephants, adding only an expression of surprise that Dr Max Schmidt should have had so little to say concerning them in his otherwise instructive memoir on 'The Diseases of Pachyderms' (quoted below).

I have but a few words to offer respecting the ectozoa. A species of mite has been described whose generic position appears doubtful. I allude to *Homopus elephantis* of Fürstenberg, or *Symbiotes elephantis* of Gerlach. According to Mégnin it is a *nymphe adventive* or *hypope* of a variety of *Tyroglyphus siro*. This acarus is abundant in old forage. Another ectozoon is *Hæmatomyzus elephantis*. It differs from the lice proper in many respects, but, according to Piaget, the reproductive organs resemble those of *Hæmatopinus*. In 'Science Gossip' for June, 1871, Mr H. C. Richter describes "a new form of parasite," which is called *Idolocoris elephantis*. The insect, which was one line in length, was found upon an elephant in Ceylon. According to Walker it not only constituted the type of a new

genus, but of an altogether new family of the Hemiptera Heteroptera, coming very near to the bed-bugs (*Acanthidæ*). It is a huge sucking louse. From the discussion which followed, it seems that the parasite had several times been seen before, and was none other than E. Piaget's *Hæmatomyzus elephantis.* Excellent figures accompany Richter's and Piaget's descriptions. Notwithstanding Piaget's explanation, I think the specific name, *longirostris*, would have been a more appropriate appellation.

BIBLIOGRAPHY (No. 51).—(Anonymous), "Diseased Elephants," see 'Lancet,' Sept. 2, 1876; also "Report of the Case at Law (Jamrach *v.* Sanger)," given in the 'Veterinarian,' Dec., 1877, p. 886.—*Cobbold, T. S.*, "Description of a species of Trematode from the Indian Elephant, with remarks on its Affinities," 'Quart. Micros. Journ.,' Jan., 1869; see also 'Entozoa,' supp., 1869, p. 80.—*Idem*, "On the Destruction of Elephants by Parasites, with remarks on two new species of Entozoa and on the so-called Earth-eating habits of Elephants and Horses in India," 'Veterinarian,' Oct., 1875.—*Idem*, "Further Remarks on Parasites from the Horse and Elephant, with a notice of new Amphistomes from the Ox," *ibid.*, Nov., 1875.—*Diesing* (l. c., in text).—*Fitz, R. H.*, "Anatomy of *Fasciola Jacksoni*," 'Rep. of Boston Soc. Med. Sci.,' in the 'New York Med. Journ.,' Nov., 1876.—*Fleming, G.*, "The Diseases of Elephants" (chiefly from Captain Forsyth's work on the 'Highlands of Central India'), 'Veterinarian,' March, 1873, p. 181.—*Mégnin*, "Mém. sur les Hypopes," in Robin's 'Journ. de l'Anat. et de la Physiol.,' 1874 (*H. elephantis*), p. 248.—*Ouchterlony, J. W.*, "An Essay on the Management of the Elephant, and its Treatment in ordinary Diseases," 'Rep. of Vet. Med. Assoc.,' Nov., 1872, and pub. in 'Veterinarian,' Jan., 1873, p. 65.—*Piaget, E.*, "Description d'un parasite de l'éléphant," 'Tijschrift voor Entomologie,' 1869, p. 249.—*Richter, H. C.*, "A new form of Parasite (*Idolocoris elephantis*)," 'Science Gossip,' 1871, pp. 131, 185, 211, 278.—*Schmidt, Max*, "Die Krankheiten der Dickhäuter," 'Deutsche Zeitschrift f. Thiermed. und vergleichende Pathologie,' f. Nov., 1878, s. 360.—*Williamson, T.*, 'Oriental Field Sports,' London, 1807, vol. i, p. 138.

The parasites of the *Rhinoceridæ* have been even less studied than those of elephants. In 1856 Prof. Peters described a tapeworm from Bruce's rhinoceros (*R. Africanus*), which he named *Tænia gigantea.* In 1870 Dr Murie, under the provi-

sional name of *T. magna*, published a description of the strobile of the same cestode from an Indian rhinoceros (*R. unicornis*). From a total misconception of the character of the proglottides, Murie was led to suppose that the segments of the strobile were very deep as well as broad; whereas the proglottids are remarkably narrow, thus partaking of the characters of the Tæniæ of the larger herbivora in general. In a subsequent paper Peters pointed out these errors. Murie had, in fact, rolled several segments into one. In 1877 Professor Garrod encountered the same cestode in *Rhinoceros sondaicus*, and, following Peters' example, separated it from the Tæniæ proper (*Plagiotænia gigantea*). The idea of generically separating tapeworms possessing a more or less striking breadth of strobile is not one which commends itself to my view, seeing that many of the tapeworms of herbivora closely resemble the rhinoscerine cestodes in this respect. As Diesing hints, this tapeworm comes near to *T. perfoliata*, but Garrod's and Peters' figures both show that *Plagiotænia* wants the neck-lobes. The presence of cephalic appendages may be regarded as generically distinctive, but it does not appear that Blanchard separated the perfoliate tapeworm of the horse from the Tæniæ proper on this ground. Therefore, in my account of the equine tapeworms, I have not adopted his genus *Anoplocephala*. I may remark, in passing, that if the distinctions, as between armed and unarmed, or between proboscis-bearing (*Rhynchotæniada*) and non-proboscis-bearing tapeworms (*Arynchotæniada*), are to be maintained, they should be expressive of divisional or subordinate value. Dr Weinland's arrangement, having reference to the thick- and thin-shelled ova (Sclero- and Malaco-leptidota), is, perhaps, preferable. The whole subject of classification requires revision, but it should be undertaken by some helminthologists practically acquainted with a large number of cestode types. As Garrod has well observed, *Plagiotænia* enjoys a wide geographical distribution, infesting alike Indian and African hosts. Prof. Garrod, I observe, speaks of the *head* of the mature tapeworm as the *scolex*—an extension of the meaning of a term not usually recognised. In this, however, he only follows Peters' unfortunate example.

The wide distribution enjoyed by Peters' Plagiotænia is probably equalled by that of the rhinocerine stomach-bot (*Gastrophilus rhinocerontis*, Owen). This parasite was originally described in 1840, and since that time it has been fre-

quently encountered both in India and Africa. To Mr Spooner Hart, of Calcutta, I am indebted for a large number of specimens; their size exceeding that of any other bots that have come under my notice. Probably this parasite infests the stomach of rhinoceroses generally; at all events, it occurs in *R. unicornis, R. bicornis,* and *R. simus.* At present the imago is unknown. The longest larvæ in my possession measure 1⅛″, but Brauer records specimens up to 35 mm. in length by 10 mm. in thickness. In African hosts M. Delegorgue found these parasites in prodigious numbers.

Bibliography (No. 52).—*Brauer,* "Bot of the Rhinoceros," 'Monogr. der Œstr.,' 1863, s. 92.—*Cobbold,* "Note on Parasites presented by Messrs Danford, Hart, and others," 'Veterinarian,' 1875, p. 513.—*Coquerel* and *Sallé,* in 'Ann. Soc. Entom. de France,' 1862 (quoted by Brauer).—*Delegorgue,* 'Voyage dans l'Afrique' (quoted by Brauer).—*Garrod,* "On the Tænia of the Rhinoceros of the Sunderbunds (*Plag. gig.,* Peters)," 'Proc. Zool. Soc.,' Nov. 20, 1877, p. 788.—*Hope,* in 'Trans. Entom. Soc.,' 1840, p. 259.—*Joly, M. N.,* "Recherches Zool. (&c.) sur les Œstrides (&c.)," in 'Ann. des Sciences (&c.) de Lyon,' 1846 (quoted by Brauer).—*Murie, J.,* "On a probably new species of Tænia (*T. magna ?*) from the Rhinoceros," 'Proc. Zool. Soc.,' 1870, p. 608.—*Peters, W.,* "Note on the Tænia from the Rhinoceros, lately described by Dr J. Murie," 'Proc. Zool. Soc.,' 1871, p. 146.

Very little has been written respecting the parasites of the *Hippopotamidæ* and *Tapiridæ.* I think it was Livingstone who first drew attention to the fact that the river-horse or sea-cow is much infested by tapeworms, but I have not seen any published description of the worm. Dr. Murie, during his sojourn in Egypt, found a solitary bot embedded in the soft parts surrounding the eye, and judging from his figure the species is new to science. Provisionally I speak of it as the *Hypoderma Muriei.* In the paper (quoted below) Murie appends a list of all the animals in which bots have been found. Though chiefly taken from Brauer, it is useful and tolerably complete. So far as I am aware no cestodes have been described as infesting tapirs; nevertheless, at least five other kinds of helminth have been found in *Tapirus Americanus.* Of these, two are flukes (*Amphistoma asperum* and *A. pyriforme*), and three are nematodes (*Sclerostoma monostechum, Spiroptera mediospiralis,* and *Sp. chrisoptera*). The three species first named occupy the cæcum,

whilst the others are found in the stomach. According to Molin's description, both species occupy tuberous excrescences of the mucous membrane, thus reminding us of the similar habit enjoyed by *Sp. megastoma* in the horse. The *Sp. chrysoptera* is a comparatively large species, the males measuring an inch, and the females as much as an inch and a half in length. Both of the spiropteras were obtained from tapirs by the indefatigable Natterer, *Sp. mediospiralis* being also procured by him from the aguti. If I have read Molin correctly, as many as thirty-four examples of *S. mediospiralis* were taken from a single excrescence in the stomach of the tapir. Upwards of a hundred specimens were procured, collectively, from three similar stomach-excrescences in *Dasyprocta aguti.* These, and the other tapirine parasites above mentioned, were originally discovered in Brazil.

Bibliography (No. 53).—*Diesing,* "Neue Gattungen Binnenwürmern nebst enem Nachtrage zur Monographie der Amphistomen," in 'Annalen d. Wien. Museums,' Feb., 1839, s. 236.—*Idem,* 'Systema,' Bd. ii, s. 306.—*Molin,* "Una monografia del genere Spiroptera," in 'Sitzungsb. der math.-naturw. Cl. d. k. Akad. d. Wissensch.,' Bd. xxxviii, s. 1001, 1859.—*Murie,* "On a larval Œstrus found in the Hippopotamus," 'Proc. Zool. Soc.,' 1870, p. 78.

The osculant position of the anisodactyle pachyderms (*Hyracidæ*), formerly classed as rodents, renders it desirable that their parasites should be briefly noticed in this place. Probably these animals, zoologically speaking, come nearest to the rhinoceroses, but Prof. Owen showed that, anatomically, they possessed marked affinities with the sloths. The klipdas or dasse (*Hyrax capensis*) is infested by a tapeworm, of which hitherto the proglottides only appear to have been seen (*Tænia hyracis,* Pallas). Under the name of *Cœnurus serialis* a larval cestode has been described by Gervais, the same parasite being called *Arynchotænia critica* by Pagenstecher ("Zur Naturgeschichte der Cestoden," in 'Sieb. u. Köll. Zeitschrift'). A variety of nematodes have also been observed in the Cape hyrax. Of these, the so-called *Physaloptera spirula* is classed as doubtful by Molin and Diesing. Hemprich and Ehrenberg furnished brief descriptions of four other nematodes. Two of these worms were placed in the genus Oxyuris (*O. pugio* and *O. flavellum*), and the other two in the new genus Crossophorus, which they formed for their reception (*C. collaris* and *C.*

tentaculatus). The whole of these nematoids were obtained either from the cæcum or large intestine.

An able article in the 'Natural History Review' for July, 1865, attributed to Professor Huxley, expressed very clearly the popular notion as to the great danger of the flesh of swine considered as a source of human parasites. No doubt the filthy pachyderms in question (*Suidæ*) are much infested by helminths, some of which gain access to man, but swine are neither attacked by a greater variety of entozoa than other domesticated animals, nor are they so frequently a source of human tapeworms as cattle. In the article above quoted the following passage occurs :—" Of all animals, feral or domestic, the common pig is beyond all doubt the most fertile source of human entozoa ; at least, of important parasites, *Trichina spiralis* and the tapeworm would, there is good reason to believe, cease to infest us, did not this favorite quadruped act the part of a communicating medium." This paragraph was evidently written under the impression that "the tapeworm" most commonly found in man was derived from the hog. So far back as 1864 I showed that this was an entire mistake.

Flukes are rare in swine; nevertheless, *Fasciola hepatica* and *Distoma lanceolatum* are occasionally present in the domestic hog, and the peccaries (*Dicotyles*) are infested by an Amphistome (*A. giganteum*). This large species, $\frac{3}{4}''$ in length, formed the basis of an admirable account of the anatomy of this genus of worms which the learned Vienna helminthologist, Diesing, wrote before he was deprived of his eyesight. The merits of that respected systematist's investigations have, I think, been much underrated, in consequence, no doubt, of the artificial character of his system of classification. For all that, his writings remain invaluable. Turning to the cestodes of swine, there is not, so far as I am aware, any evidence of the occurrence of sexually-mature tapeworms either in the hog or its allies; but the frequency of larval cestodes, known as measles (*Cysticercus telæ cellulosæ*), was well known to the early Jewish writers. In the first part of this work I devoted as much space as I could spare to the consideration of Cysticerci in general, and the pork-measle in particular; but an exhaustive knowledge of the subject in relation to hygiene can only be acquired by consulting the principal original memoirs (quoted in the Bibliographies Nos. 13 and 14). In a Westphalian ham, part of which was sent to me for examination, I calculated that

each pound of the flesh must have contained upwards of 600 Cysticerci. I was informed by the donor, Dr Prior, that in spite of the disgusting state of the meat much of it had been eaten by the well-to-do family who purchased the ham. Cysticerci occasionally occupy the brain of the pig in considerable numbers. Florman recorded a case of this kind where their presence gave rise to vertigo in all respects resembling the gid ordinarily produced by *Cœnurus* in the sheep. As regards the larger cestode larvæ, *Cysticercus tenuicollis* and *Echinococcus veterinorum* are of frequent occurrence. One not unfrequently encounters the former in the mesentery, whilst the liver of the hog is sometimes so crowded with hydatids that scarcely any of the glandular substance of the organ remains visible. It is surprising how little the infested bearers appear to be inconvenienced in such cases. In the winter of 1859, and in the autumn of 1860, I found large cystic entozoa in an African Wart-hog and in a Red River hog. These animals had died at the London Zoological Society's Menagerie; and as the worms appeared to me at the time to be quite distinct from the ordinary slender-necked hydatid, they were named, respectively, *Cysticercus phacochæri æthiopici* and *C. potamochæri penicillati.* The solitary example from the wart-hog was found in a cyst near the colon; whilst of the five large bladder-worms obtained from the Red River hog, one infested the liver and the other four were lodged in the folds of the mesentery. The caudal vesicle of the worm from the wart-hog measured $3\frac{1}{2}''$ in diameter, the vesicle of the other bladder-worm being much longer. A reference to the original figures will show that these forms are distinct. Swine are largely infested by nematodes. The best-known form is *Ascaris lumbricoides*, which Dujardin regarded as distinct (*A. suilla*). The hitherto disputed identity of this worm with the human lumbricoid being no longer questionable, the importance of the entozoon in rela-

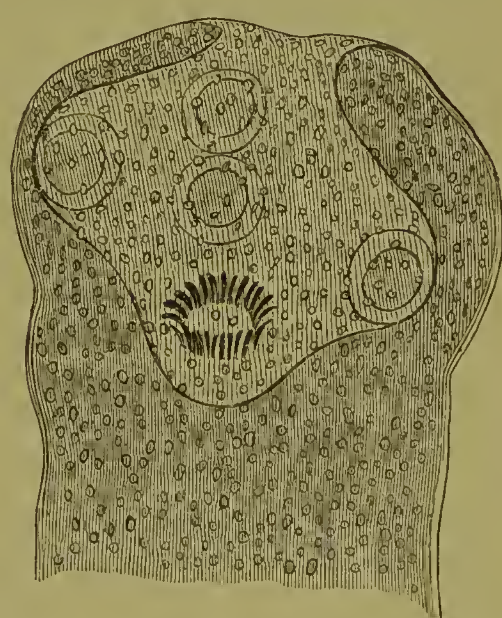

FIG. 66.—Head and neck of *Cysticercus* from the Red River hog. Magnified 60 diameters. Original.

tion to lumbricoid endemics must at once be obvious; I have already, however, dwelt upon this subject when treating of the human parasites. In like manner, the subject of the flesh-worm disease, which is due to *Trichina spiralis,* cannot be discussed in this place, as I have fully entered upon it in connection with trichinosis in the human subject. What may be the nature of the small threadworms found by Leidy in the extensor muscles of the hog I cannot say, but Diesing inferred that they might represent a distinct species (*Trichina affinis*). As regards the allied genus *Trichocephalus,* the common species infesting swine (*T. crenatus*), appears to be rarely absent. It not only infests the common domestic and wild hog, but the peccaries and wart-hogs. These entozoa are probably harmless to their bearers. In reference to them Krabbe says:—"When the eggs are expelled with the excrement and pass into water, then the embryos, after several months' furlough, and there undergoing further development, are transferred to the swine's intestinal canal." If I rightly understand the paragraph ('Husdyrenes Indvoldsorme,' p. 28), Krabbe states that the embryos are still within their egg-coverings when infection takes place. The maw-worm of the hog is known as *Spiroptera strongylina.* It was described and figured by Gurlt. The males measure $\frac{1}{2}''$ and the females $\frac{3}{4}''$ in length. Specimens of this worm were supposed to have been found by Natterer in *Dicotyles albirostris;* but it seems that the worms in question represent a distinct species, if not an altogether new genus. In the year 1864 Professor Simonds placed in my hands a very singular nematode, to which I gave the binomial term *Simondsia paradoxa.* Numerous examples of this worm were found by Prof. Simonds occupying cysts within the walls of the stomach of a hog which had died at the London Zoological Society's Menagerie. In my introductory treatise I wrote of it as follows:—"The worm in question has been regarded by Mr Simonds as a species of *Strongylus,* but I am inclined to think that its affinities will place it nearer to the genus *Spiroptera.* At present I have only examined the female, which is characterised by the possession of a multitude of large tentacle-like appendages surrounding the neck. These processes, by their aspect, remind one of the so-called branchial projections on the back of *Eolis,* but in this worm I believe them to be special folds formed for the lodgment of unusually developed uterine organs. The female worm is about $\frac{3}{4}''$ in length."

In the interval that has elapsed I have been unable to supply further particulars, and unfortunately the original drawings of the worm have been lost. The habits of the parasite remind us of *Spiroptera megastoma* infesting the walls of the stomach of the horse. Not improbably this singular entozoon may turn out to be identical with Molin's *Spiroptera sexalata*, and if so, it may correspond with *Spiroptera strongylina*. However, Diesing afterwards recognising, as I had done, the desirability of separating this last-named worm from the Spiropteræ proper, formed for it his new genus *Physocephalus*. He then called the worm *Physocephalus sexalatus*. If, as is probable, my *Simondsia* and Diesing's *Physocephalus* are identical, the species found by Simonds ought to be recognised by the generic title which Diesing proposed. His genus was established about four years before I described my *Simondsia*. Diesing was evidently led up to the recognition of the generic distinction of the worm by Molin's examination and description of the worm. As, in my original account of the worm found by Simonds, I spoke of numerous appendages to the neck, it is evident that further investigation is necessary to clear up the question of identity. According to Molin and Diesing the male *Spiroptera sexalata* measures rather beyond $\frac{1}{4}''$ and the female beyond $\frac{1}{2}''$ in length. Neither Diesing nor Molin speak of Natterer's worms as being found encysted. In fact they were free. Molin simply remarks :—" Io ne esaminai in oltre 6 esemplari maschi e 77 femine raccolti in parte dal muco che revestiva le pareti dello stomaco, ed in parte dal pasto contenuto nello stesso organo di un *Dicotyles albirostris* femina ai 24 Aprile, 1826." After all that has been said it may be that my *Simondsia paradoxa* and Diesing's *Physocephalus sexalata* are quite distinct, and that like the large- and small-mouthed maw-worms of the horse (*Spiroptera megastoma* and *S. microstoma*) they play a corresponding rôle. Before very long I hope to set this question definitively at rest.

Passing to the strongyloid nematodes one of the most remarkable and important species is *Stephanurus dentatus*. In the 'Annalen des Wiener Museums' for 1839 (s. 232) this worm was first described by Diesing, who employed the generic title as expressive of the crown-like figure of the tail of the male worm. Diesing wrote as follows :—" At Barra do Rio Negro, on the 24th of March, 1834, Natterer discovered this peculiar genus of worms occurring singly or several together in capsules situated

amongst the layers of fat in a Chinese race of *Sus scrofa domestica*. The males measure from ten to thirteen lines long, the females from fifteen to eighteen lines, the former being scarcely a line in breadth at the middle of the body, whilst the latter are almost a line and a half in thickness. The curved body thickens towards the tail, is transversely annulated, and viewed with a penetrating lens is seen to be furnished with integumentary pores. The oral aperture opens widely. It is almost circular, and is supplied with six teeth at the margin. Two of these standing opposed to one another are larger and stronger than the rest. The tail of the male, when spread out evenly, is surrounded by a coronet of five lancet-shaped flaps; the combined flaps being connected together from base to apex by means of a delicate transparent membrane. The single spiculum situated at the extreme end of the tail projects slightly forward and is surrounded by three skittle-shaped bodies. The tail of the female is curved upon itself, rounded off, and drawn out at the extreme end into a straight beak-shaped point; whilst to both sides of the stumpy caudal extremity of the body short vesicular prominences are attached. The female reproductive outlet occurs at the commencement of the second half of the body. Thus, judging by its external characters this genus is most closely allied to *Strongylus*." In reproducing Diesing's description I have here rendered the translation somewhat more freely than in my previous record of the discovery given in 'Nature' (1871). The original description is supplemented by a brief account of the internal anatomy of the worm.

So far as I am aware no subsequent notice of this entozoon appeared until the year 1858, when Dr J. C. White gave some account of a "find" made in the United States. This re-discovery was reported in the sixth volume of the 'Proceedings of the Boston Natural History Society.' Dr White says:—"The worms were found in the leaf-yard of an apparently healthy hog, in the adipose tissue near the kidney. They occupied a space of the same about the size of a man's fist and had burrowed through the mass in every direction, forming canals three or four millimètres in diameter, which terminated in cysts. On cutting open these cavities, which did not communicate with each other, they were found filled with pus, and in each were two worms, male and female." Dr White expresses his opinion that the worms gained access to the tissues "by boring through the circulatory

system while in the embryonic condition." I think that Dr White deserves great credit for his correct diagnosis of the species, and all the more so because he was evidently not acquainted with Diesing's original memoir. He expressly speaks of the "scanty descriptions" hitherto given of the worm. As Dr White had accurately determined the species in the presence of an American Scientific Society, it is remarkable that neither Verrill nor Fletcher should have identified the worm.

On the 10th of January, 1871, I received a letter from Prof. W. B. Fletcher, of Indianapolis, Indiana, U.S.A., and in it he announced that he had "found a worm" infesting the hog. The parasite was so abundant in swine that he obtained it in "nine out of ten hogs" which he had examined. Dr Fletcher sent me specimens of the worm for description and identification, when I at once recognised them as examples of Diesing's *Stephanurus dentatus*. As Dr Fletcher's first communication to myself was undated I do not know precisely when he first encountered the worm, but it was in 1870. In that same year Prof. Verrill received specimens of the worm. He says that they were received from Dr J. C. White. Failing to identify the parasites as *Stephanuri*, Verrill (making no allusion to the 'Proceedings of the Boston Society') not unnaturally supposed he had to deal with an entozoon that was new to science. Accordingly he immediately described and figured the worm under the combined title of *Sclerostoma pinguicola*. If these data are correctly given, the re-discovery of the worm in America was due to Dr J. C. White; its identity with *Stephanurus* being subsequently acknowledged by Diesing, and afterwards, quite independently, by myself. I gather this partly from Diesing's 'Kleine helminthologische Mittheilungen' (s. 281), published as a supplement to his 'Revision der Nematoden' (1860–61). Until quite recently Diesing's recognition of the identity of White's parasites with Stephanuri was unknown in America. My conclusions arose from an examination of the actual specimens, whereas Diesing was entirely guided by White's description. In this connection, moreover, a still more interesting re-discovery remained to be recorded. The original announcement which I made in the 'British Medical Journal' for January 14th, 1871, was followed by another in the same periodical for September, 1871. As stated in my second letter and repeated in my notice of Krabbe's

memoir on "Parasites" ('London Medical Record,' April 2, 1873), the President of the London Microscopical Society (through Mr Slack, who was at that time the secretary) forwarded to me a box of microscopic slides received by the Society from Australia. The slides displayed parasites of various kinds. Having been requested to identify the parasites I had the good fortune to recognise amongst them characteristic examples of *Stephanurus dentatus*. Thus was first made known the fact that this singular genus was not confined in its geographical distribution to the two American continents, but that it extended to Australia. The order of the principal "finds" and descriptions may therefore be thus restated. Natterer discovered the worm in Brazil in 1834. Diesing described it in 1839. Dr J. C. White re-discovered and identified the worm in 1858. It was subsequently found by Dr N. Cressy and by Dr Fletcher. These three observers all encountered the parasite in the United States (1858–70). Prof. Verrill re-described the worm as new to science in September, 1870. Diesing confirmed White's diagnosis in 1860. I identified the worm from Fletcher's "find" in 1871. Dr Morris supposed he had discovered a new entozoon in Australia in July, 1871. The Australian worms were identified by me as examples of *Stephanurus dentatus* in October, 1871.

The importance of *Stephanurus* in relation to porcine epizoöty and the supply of animal food cannot be ignored. As remarked in my communication to 'Nature,' it must be quite obvious that so large a parasite, when present in the hog in any considerable numbers, would give rise to serious disease, even if it were not productive of fatal results to the bearer. In one of his numerous communications to myself, Prof. W. B. Fletcher writes as follows:—"It is my opinion that this parasite is the cause, in some way, of the hog cholera, which has created such sad havoc within the past ten years over the pork-producing parts of America. One farmer told me, a few days ago, that within a month his loss alone from this cause was over one hundred head; and sometimes, in one neighbourhood, in a few days' time, thousands have perished, although this season is not a cholera year, as our farmers say. I advised one farmer to burn or bury the dead animals, but he informed me that he believed that fewer hogs die of the disease after eating the dead animals than those kept from them. Unfortunately, in this State there is no law guarding the spread of disease,

neither is there any reward of reputation or gain for pursuing any investigation that would bring pork and beef packers into disrepute. I myself could not get a pig's kidney or beef's liver in our city market, because I made investigations in some Texas cattle (being cut up in our market), which damaged their sale a few years ago." In a third letter Dr Fletcher tells me that greater facilities for examining the carcases of hogs had since been accorded him through the liberality of a Liverpool firm of pork-packers, who had already killed 75,000 hogs during the summer season, *i.e.* up to the date of the first week in July. In hot weather the slaughtering is conducted in ice-houses. Prof. Fletcher's views receive confirmation from the statements made by Dr Morris, who speaks of the pigs as dying from some mysterious disease, and thinks that the worms may be the cause of the porcine mortality. Writing to the President of the London Microscopical Society from Sydney (July 12th, 1871), Dr Morris says:—"It is just possible that some pigs may survive the irritation such a swarm of young worms must set up; others, again, may die from peritonitis, hence the sudden deaths amongst the pigs." I think Dr Morris' view is perfectly correct, but whether it be so or not, it is (as observed by me in 'Nature') interesting to notice the remarkable correspondency of the conclusions arrived at by Drs Fletcher and Morris independently. It will probably not be difficult to ascertain hereafter whether or not the maladies respectively termed "hog cholera" and "mysterious disease" are one and the same disorder, but whatever happens in this respect, it is now quite clear that this parasite, hitherto little regarded, and for many years past persistently overlooked, is extraordinarily prevalent in the United States, and, perhaps, equally so in Australia; it being further evident that its presence in the flesh of swine is capable of producing both disease and death. The statement of the worthy American farmer that the swallowing of infested flesh by pigs does not necessarily involve the pig-eating hog in a bad attack of the so-called "cholera disease" requires to be further tested, and it also remains to be proven whether or not the *Stephanurus* be capable of passing through all its developmental changes from the egg to the adult form within the body of the bearer without having at some time or other gained access to the outer world. The comparatively large size of the ova, which I find to be about $\frac{1}{300}''$, or more than four times the size of Trichina-eggs, is not with-

out significance, but as yet we are entirely unacquainted with the larvæ of *Stephanurus.* If no intermediary bearers are necessary to its development, we ought not to have to wait long for a complete record of the life-history of *Stephanurus dentatus.* In conclusion, I will only further remark that since thousands of hogs are infested by this entozoon the subject is worth further investigation. I believe that Prof. Fletcher brought the matter under the notice of the United States National Swine Breeder's Association, which met at Indianapolis in November, 1872, but with what success I have been unable to learn. The wealthy agricultural societies of Great Britain pay little or no regard to the subject of parasites, although thousands of valuable animals annually perish from the injurious action of entozoa.

Of the remaining nematodes infesting swine I must particularly mention *Sclerostoma* (*Strongylus*) *dentatum* and *Strongylus paradoxus,* the last named being generally regarded as identical with Dujardin's *S. elongatus.* The first of these two parasites infests the small intestines, the male and female worms alike measuring about ½″ in length. The females are sometimes a trifle longer. The *Sclerostoma dentatum* is an abundant parasite, infesting all varieties of swine and also peccaries; but it is apparently incapable of serious injury to the bearer. Schneider selected the male *S. dentatum* for classificatory purposes. In this worm the arrangement of the rays of the hood is simple, forming a good central type. Dr D. V. Dean, in his excellent report of St Louis Board of Health (1874), speaks of *Strongylus dentatus* as if it were the same entozoon as *Stephanurus.* The confusion of nomenclature would have been avoided if Diesing had called the renal worm *Stephanurus Nattereri.* I hope this title will yet be adopted to prevent future mistakes. The lung-worm (*S. paradoxus*) is by no means harmless, being a frequent cause of fatal husk in young pigs. It is a viviparous worm, the females acquiring a length of 1½″, whilst the males rarely exceed ¾″. Under the title *Gongylonema pulchrum,* Molin has noticed yet another filariform nematode infesting the wild hog; and, lastly, the lamented Russian traveller, Fedschenko, has published a full description of a new species of Gnathostoma (*G. hispidum*), which infests the coats of the stomach alike of the wild and domestic hog. One of the most interesting parasites of swine is the large acanthocephalous entozoon (*Echinorhynchus gigas*). It infests the small intestines both of the wild and domesticated hog, and

it was also obtained by Natterer from the collared peccary of Tayazou. Common as the great Echinorhynchus is in the United States (and it is scarcely less so on the Continent) I believe that few, if any, of the museums in the United Kingdom of Great Britain contain this large entozoon. It is a curious fact that it does not exist in the Hunterian Collection, where, however, there is displayed a very fine set of acanthocephalous parasites from whales. When in the year 1865 I mounted, with my own hands, 200 preparations of entozoa for the Museum of the Royal College of Surgeons, I had not so much as seen a specimen of this worm. Much scientific interest attaches to this parasite from the fact that Schneider discovered that the embryos of *E. gigas* take up their residence in the larvæ of the cockchafer (*Melolontha vulgaris*). He thinks it identical with the *Echinorhynchus hominis* of Lambl. Leuckart disputes this identity, and compares Lambl's worm with the *Echinorhynchus angustatus* of our fresh-water fishes. The *E. spirula* of certain Brazilian monkeys and of the Barbary ape bears a strong resemblance to the species from the hog. On the strength of Lambl's case—and it is the only genuine instance of the kind on record—Prof. Leuckart devotes no less than 125 pages of his great work to the consideration of the structure and development of the thorn-headed intestinal worms. This worm demands especial attention. Speaking of the hog's Echinorhynchus, Prof. Verrill, in his 'Connecticut Report,' says that "sometimes the intestine of a hog is found perforated by so many holes that it cannot be used in the manufacture of sausages." From Mr George Wilkins I learn that the pig-slaughterers of our English metropolis are well acquainted with these perforations, which are sometimes so numerous that the gut looks as if it had been "riddled" with swan-shot. No wonder that diseased hogs, afflicted with these formidable parasites, go about, as Verrill expresses it, "continually squealing and grunting, especially in the morning." That they are also "cross and morose, and given to biting and snarling at their companions," is by no means astonishing. "In severe cases," remarks Verrill, "hogs afflicted with this parasite are weak in the loins, and have the membranes in the corners of the eyes swollen, watery, and lighter colored than usual." It is some comfort to know that Lambl's human case is unique, and that so long as people abstain from eating cockchafer larvæ they are not likely to be infested by *Echino-*

rhynchus gigas. In the first book of this work I have given my reasons for not regarding Welch's "encysted *Echinorhynchus* in man" as a genuine example of this curious genus of entozoa.

The external parasites of swine are not so numerous as might be expected from the habits of their hosts. The most common ectozoon is the hog louse (*Hæmatopinus suis*). This disgusting little insect is about $\frac{1}{8}''$ in length. Almost equally common is the hog mite. Though hitherto considered as a distinct species (*Sarcoptes suis*, Gurlt), it is regarded by Mégnin as a mere variety of *Sarcoptes scabiei*. As Gerlach and others have remarked, it is readily transmissible to man. The *Sarcoptes squammiferus*, of Fürstenburg, is only another name for this variety of *S. scabiei*. Speaking of this scab-insect Mégnin says:—"This parasite was first encountered by Spinola and Gurlt, and afterwards by Müller." He then adds:—"A Ceylon wild boar died at the menagerie of the Museum of Paris of a chronic affection of the skin which had transformed its integument into a vast *lichen*." Lastly, as regards the protozoal parasites I can only remark that the psorosperms (spoken of as Rainey's corpuscles or as Miescher's utricles) are often very abundant in the flesh of otherwise perfectly healthy swine. Having dwelt upon the character of such organisms in the first moiety of this work, I will only remark that the full significance of these singular bodies yet remains to be determined. Rainey's notion that they represented early stages of cysticercal growth is altogether untenable. According to Behrens, as quoted by Davaine, psorosperms are especially abundant in the flesh of swine which have recovered from the disease called *mal rouge*. On the subject generally, the writings of Rivolta, Waldenburg, Eimer, and Siedamagrotsky are especially trustworthy. Full references to these and other authorities are given in the synopsis of the 2nd edition of Davaine's well-known treatise.

Bibliography (No. 54).—(Anonymous), "On Parasitic Maladies, especially Measles, of the Pig," from 'Scottish Farmer and Horticulturist,' in 'Edin. Vet. Rev.,' p. 688, 1861.—*Ballard, E.*, "On Diseased Meat, and what to observe in cases of suspected Poisoning by Meat or Sausages (infected with Entozoa, &c.)," 'Med. Times and Gaz.,' Jan., 1864.—*Bowditch, H. J.*, "Raw Pork as an Aliment (without reference to the question of Entozoa.—T. S. C.)," 'Boston Med. and Surg. Journ.,' vol. lv,

1857; see also 'Comments,' vol. lvi, pp. 23 and 69, 1857.—*Cobbold*, "On the Discovery of Stephanurus in the United States and in Australia," in 'Nature,' Oct. 21, 1871, p. 508, and in 'Brit. Med. Journ.,' Jan. and Sept., 1871; also in the 'Monthly Micros. Journ.,' Nov., 1871.—*Idem*, "Internal Parasites of the Hog," in 'Manual,' chap. xii.—*Idem*, "On Cystic Entozoa from the Wart-Hog and Red River Hog.," 'Proc. Zool. Soc.,' 1861.—*Idem*, "On Simondsia," 'Entoz.,' p. 79.—*Idem*, "Note on Worms in the Lungs of a Pig," in the 'Field' for Jan. 9, 1864.—*Idem* (in relation to Cysticerci or Measles, see Bibl. Nos. 13 and 14, and, for remarks on psorosperms, Bibl. No. 41).—*Cressy, N.*, 'On the Diseases of Domestic Animals in Connecticut (2nd and 3rd Ann. Reports),' Hartford, U.S., 1873–74.—*Idem*, "The demands of Agriculture on Veterinary Science," in 'Rep. of the Mass. Board of Agric.,' 1874.—*Idem*, 'Find of Sclerostoma' (quoted by Verrill).—*Crisp*, "Note on Hydatid Cysts in the Abdominal Cavity of various Hogs," 'Path. Soc. Trans.,' 1863.—*Dardel* (see Bibl. No. 14).—*Davaine* "Ladrarie chez le porc," in his 'Traité,' 2ème edit., p. 668 (see also the writings of Delpech, Guardia, and especially Reynal, quoted at p. 674).—*Dean, D. V.*, "On Meats and Parasites," in 'Seventh Ann. Rep. of Board of Health of the City of St Louis,' 1874, p. 58 *et seq.*—*Diesing*, 'On Stephanurus' (quoted in text above).—*Dupuy*, "Hydatid in a Pig," from 'Journ. Théorique et Prat.,' in the 'Veterinarian,' vol. iv, 1831, p. 285.—*Fedschenko*, 'Description of new Species of Tetrastemma, Prorhynchus, and Gnathostoma' (in the Russian language), Moscow, 1872.—*Fleming, A.*, "Measly Pork as Food for Man," 'Edin. Vet. Rev.,' vol. i, p. 485, 1858–59.—*Idem*, "On the Measle of the Pig, and on the Wholesomeness, as Food for Man, of Measly Pork," 'Dubl. Quart. Journ.,' 1857.—*Fletcher* (quoted in text above).—*Florman* (quoted by Rudolphi, 'Synops.,' p. 620, 1819; and by Davaine, l. c., p. 723, 1878), in 'Vetensk. Acad. Nya Handlingar,' 1810, pp. 179-182.—*Gairdner, W. T.*, "Case of Tapeworm occurring in connection with the Eating of Raw Pork," 'Edin. Month. Journ.,' 1856, and in the 'Veterinarian,' vol. xxix, p. 228, 1856.—*Gamgee, J.*, "On Diseased Meat," 'Pop. Science Rev.,' Jan., 1861.—*Gordon*, "On Tapeworm from Unwholesome Food," 'Med. Gaz.,' 1857.—*Gross, S. D.*, "Note on the frequency of Acephalocysts in Swine at Cincinnati," in his 'Elements of Path. Anat.,' p. 118, 1845.—*Gurlt, E. F.*, 'Lehrbuch der path. Anat. der Haus-

Saügethiere,' 1831, s. 46, 51, 142, 385.—*Heller* (see Bibl. No. 13).—*Krabbe,* 'Husdyrenes Indvoldsorme' (l. c., in text; see also review in 'Lond. Med. Rec.,' April 2, 1872, p. 206).—*Leidy,* "Note on *Trichina spiralis* from the Pig," from 'Rep. Acad. Philad.,' in 'Ann. Nat. Hist.,' vol. xix, 1847.—*Leuckart* (see Bibl. No. 13).—*Lewis* (Bibl. No. 13).—*Martin, J.,* "Case of Hydatids in the Liver of a Sow," 'Trans. Vet. Assoc.,' pp. 330 and 364, 1842-43.—*Mégnin* (Bibl. No. 14).—*Molin,* 'Una Monog. del Gen. Spiroptera,' Wien, 1860.—*Morris,* "Report on Australian Parasites," 'Month. Microsc. Journ.,' Nov., 1871. —*Percy, S. R.,* "On Diseased Meat in relation to Public Health (Prize Essay)," 'New York Med. Journ.,' 1866.—*Idem,* "On the Food of Cities (an Address)," 'New York,' 1864.—*Perroncito* (Bibl. No. 13).—*Putz* (Bibl. No. 14).—*Rainey* (Bibl. No. 14).—*Rigetti* (Bibl. No. 14).—*Sawer, A.,* "Trichina," in 'Bost. Med. and Surg. Journ.,' 1865, p. 16.—*Schmidt, Max* (see Bibl. No. 51).—*Tartivel* (Bibl. No. 14).—*Thudichum* (Bibl. No. 13).—*Tommasi* (Bibl. No. 13).—*Verrill,* "On Sclerostoma," 'Amer. Journ. Sci. and Arts,' Sept., 1870.—*Idem,* "The External and Internal Parasites of Man and Domestic Animals," from 'Rep. of the Conn. Board of Agriculture,' 1870, p. 109.—*Walker* (see Bibl. No. 20, *o*).—*Wheeler, E. G.,* "Worms in the Lungs of Swine," 'Bost. Med. and Surg. Journ.,' 1841.—*White, J. C.,* "On Stephanurus," 'Proc. Bost. Nat. Hist. Soc.,' vol. vi, p. 428, 1858.

Part XI (Cetacea).

The parasites of whales are excessively numerous. Unfortunately only a few of the species have been carefully studied, and much confusion necessarily exists as to the number of distinct forms. This statement is especially applicable to the entozoal group, which comprises upwards of a score of species. Probably Van Beneden has examined more of these parasites than any one else, and what little is known respecting them is for the most part due to his investigations. I have myself encountered and described several new species—a circumstance which Prof. Van Beneden appears to have altogether overlooked.

Commencing with the flukes, the first species I notice is *Distoma lancea.* The late C. M. Diesing's description of this

worm was based upon specimens obtained by Natterer in Brazil. The worms were discovered in the biliary ducts of a male dolphin dissected at Barra do Rio Negro on 29th December, 1833. Natterer calls this cetacean the tacuschi, and in a letter to Diesing names the species *Delphinus tacuschi,* in order to distinguish it from the *D. amazonicus* of Spix and Martius. Prof. Flower has shown that Spix and Martius's *D. amazonicus* is referable to the inia or Bolivian dolphin (*Inia Geoffroyi*). The views of Flower, Natterer, and Diesing are thus far in agreement; and the geographical position of Barra shows that Natterer's dolphin could not be the inia, since, as Blyth long ago remarked, this last named cetacean "inhabits only the remote tributaries of the Amazon and the elevated lakes of Peru." Several other dolphins from Brazil have been described, one of which Mr Gray named *Steno tacuxi.* I think that Gray's cetacean answers to the *Delphinus tacuschi* of Natterer; but Prof. Flower is of opinion that Gray's species is an ordinary Delphinus. In this case it may, he thinks, probably be referred either to the *D. fluviatilis* or to *D. pallidus.* Whichever view is correct, it is clear that Natterer's parasite was obtained from a fluviatile cetacean, and not from an oceanic or even an estuary form. In Diesing's original description it is stated that Natterer found the *Distoma lancea* "once only," when numerous examples were secured. To Dr Anderson I stand indebted for a solitary specimen, which he procured from the short-snouted dolphin (*Orcella brevirostris,* Owen). The obliging superintendent of the Calcutta Museum obtained this Distoma on the 3rd of January, 1873. He removed it from the duodenum, but it had probably escaped from the liver. Be that as it may, I easily recognised the species by the sinuosities of the margin of the body. Dr Anderson's parasite does not exhibit these marginal irregularities so distinctly and sharply as they are shown in Diesing's figures. Diesing remarks that the internal organs may be seen through the transparent body. The uterine organs, crowded with ova and of a purple color, are represented by him as branched after the fashion of a raceme. The artist has been misled. The uterine channel is

FIG. 67.—*Distoma lancea.* Original.

not branched. Dr Anderson's specimen showed two large oval testes placed one above the other in the middle line, and rather higher up than is usual with those distomes that have the organs presenting this simple form. The ducts were not visible. The yelk-forming glands were particularly well marked, consisting of two laterally-disposed masses, the left gland extending higher up than its fellow. The so-called yelk-cells or capsules were well seen. The oval-shaped eggs were tolerably distinct, yielding a length of $\frac{1}{750}''$ from pole to pole, by about $\frac{1}{900}''$ in transverse diameter. The worm, when unrolled, did not exceed $\frac{1}{6}''$ at most, whereas some of Natterer's specimens measured $\frac{1}{2}''$ in length. The neck had lost that rounded character which Diesing called skittle-shaped (*kegelförmige*). The ventral acetabulum is very nearly twice as large as the oral sucker. Diesing represents the ventral sucker as circular; but in Anderson's specimen this organ was broadly oval.

The next fluke I have to notice (*Distoma Campula*) is better known to me. In the twenty-second volume of the 'Linnean Society's Transactions' I first described this new fluke, having secured numerous examples from the peripheral branches of the biliary ducts of a porpoise (*Phocæna communis*). The apparently healthy cetacean was shot by Mr Jardine Murray in the Firth of Forth, in April, 1855. I mention its condition because the bile-ducts were found to be diseased in a way similar to that ordinarily observed in cases of fluke-rot affecting sheep, cattle, and other animals. In my MS. note-book I remarked: "The liver-ducts were in several places thickened and knotted near the surface of the organ. On opening these they were found to be loaded with small distomata." It was added that, so long as the flukes were alive, they displayed under the microscope a "double and peculiar intestinal tube," the skin being clothed with spines arranged throughout with perfect regularity. When the superficial ducts were dissected out they presented a distinctly beaded appearance, the enlargements of the lumen being occupied by flukes closely packed together. At least twenty were found in one spot. One of these enlarged ducts is figured in my recent paper to the Linnean Society (quoted below). The most striking feature connected with the structure of *Distoma Campula* is the twisted condition of the digestive canals. They present a zigzag appearance, the lateral folds being so sharp that they seem to constitute, as it were, a transition between the ordinary simple intestinal tubes of a true

Distoma and the branched tubes seen in *Fasciola*. This led me originally to place the worms in a distinct genus (*Campula*). Perhaps there were no sufficient grounds for this generic separation; but in all Dr Anderson's specimens obtained from the liver-ducts of the Gangetic dolphin more or less decomposition of the contents of the intestinal tubes had occurred, consequently the angular appearance of the folds is entirely lost. From the other characters presented by the worms I believe that these flukes from the Ganges are specifically identical with those originally obtained from the porpoise of the Firth of Forth. For reasons elsewhere stated at full length I have merged my genus Campula into that of Distoma. Thus, *Campula oblonga* is a synonym only. I cannot here treat of the morphology of trematode organisation as it deserves; but in relation to the question of transition-forms I may remark in passing that an extreme degree of intestinal folding seems as if it must result in branching. This, I think, would happen should any departure from the central distome type be rendered necessary by the exigences of the creature. At all events, the spirally-twisted and branched digestive organs constitute different ways in which nature attains one and the same end. I may add that this coiled condition of the tubes in *D. Campula* is by no means unique, since I have seen it in other trematode forms, as, for example, in my *D. compactum* from the Indian ichneumon. Dr Anderson's specimens of *D. Campula* furnish a good general view of the reproductive organs. They show that the single, relatively narrow, and unbranched uterine canal is of great length, and coiled upon itself in a very tortuous manner. In this way the duct passes from side to side, crossing the central line of the body at least a dozen times, whilst every fold is likewise bent upon itself to such an extent as to increase its length to at least four times

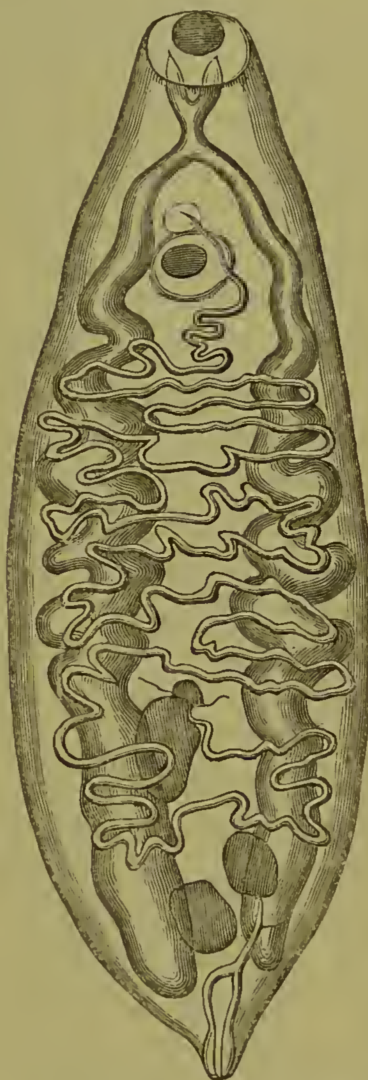

FIG. 68.—*Distoma Campula.* Original.

that of the animal. In short, the uterine folds may be described as passing from side to side, each separate coil being twisted upon itself so as to form secondary coils. In the fluke here drawn I have accurately represented every winding of the duct, from its vaginal outlet above to its termination, where it is joined by the ovarian and vitelligene ducts in the ordinary way. Only the merest traces of these smaller channels were visible ; but the two oval testes were well defined, occupying a position somewhat lower down than usual. There was a third organ, apparently the ovary. This was less well defined, and situated higher up in the middle line. The vitelligene glands occupied the usual position. The terminal cells or capsules with their efferent ducts were well seen in several specimens. The water-vascular system was constantly visible, or at least that part of the main channel which expands into a large vesicle immediately above the central point of the tail. At this part several of the specimens ruptured. In all of the worms the lower end exhibited a sort of tail, resulting from *post-mortem* changes. None of the Edinburgh specimens of Campula displayed either the slightest trace of this projection or of the water-vessel connected with it. The uterine duct was filled with eggs. Approximately, the ova gave a measurement of $\frac{1}{1000}''$ from pole to pole by $\frac{1}{2100}''$ in breadth. Although in Anderson's specimens the integumentary spines had fallen off, they are still attached in my original specimens from Edinburgh. The spines average $\frac{1}{500}''$ in length. With their shafts directed downwards they separately presented the form of a long cone, the base of which was only $\frac{1}{1000}''$ broad. After describing the above-mentioned trematodes I received a letter from Dr Anderson, in which he enclosed a sketch of a parasite taken from the small intestine of another *Platanista.* The illustration evidently represented a new species of cetacean fluke which I called *Distoma Andersoni*, with the following diagnosis :—" Body oblong, smooth externally, uniform in thickness, six times as long as broad ; head with lateral projections ; ventral sucker large and prominent ; neck much constricted; tail evenly rounded off, blunt. Length $\frac{1}{8}''$, breadth about $\frac{1}{50}''$." This worm, which was discovered by Anderson, in March, 1873, is figured in my memoir communicated to the Linnean Society. Only one parasite was found. The figure in question shows that in this species the testes are globular and placed high up in the middle line of the body. A small lobed gland immediately above the testes is probably the

ovary. The vitelligene glands are largely developed. In the year 1858 Van Beneden described a large fluke from the pike-whale (*Balænoptera rostrata*). The specimens were from Eschricht's collection and had been removed from the liver. As some of the examples measured no less than 80 millimètres, Van Beneden described them as "the largest known distomes." This is probably correct, but the great human fluke (*D. crassum*) reaches 2½″, and the giraffe's fluke (*Fasciola gigantea*) 3 inches in length. The curator of the Australian Museum, at Sydney, Mr Gerard Krefft, mentions a *Distoma* which himself and Mr George Masters obtained from *Delphinus Forsteri*. Not improbably it represents a new species. Of the single-suckered flukes, Creplin in 1825 obtained *Monostoma plicatum* from the intestines and œsophagus of a northern whale. This cetacean was obtained on the coast of the island of Rugen, in the Baltic. It has been variously spoken of as *Balæna borealis* or *B. rostrata*, but by Van Beneden this cetacean is called *Balænoptera musculus*. The flukes exceeded ¼″ in length. Another species of monostome (*M. delphini*) was vaguely indicated by Blainville as occupying the cutaneous follicles of *Delphinus Dalei*, which cetacean is a synonym of *Micropteron sowerbiensis*. The same worm is supposed by Van Beneden to infest the bottle-head (*Hyperoodon butzkopf*), and perhaps it was the same or a similar worm which Poelman found in the flesh of *Lagenorhynchus Eschrichti*. By naturalists imperfectly acquainted with helminths, the monostomes are apt to be confounded with Cysticerci; nevertheless, these widely different types may coexist in the same host. The presence of larval cestodes has been indicated in various whales. Thus, F. Cuvier and Van Beneden state that Surgeon-Major Carnot, in 1822, found an enormous quantity of small hydatids in the nasal sinuses of a porpoise (*Phocæna compressicaudata*). These are supposed to be Cysticerci. In like manner Mr F. D. Bennett, in 1837, obtained numerous capsuled Cysticerci from the skin and blubber of *Catodon* (*Physeter*) *macrocephalus*. It is unfortunate that so few of the cetacean helminths find their way into the hands of persons competent to decide upon their true character.

Mr Bennett's "find" was originally stated to have been made in *Balæna mysticetus*, but Van Beneden refers it to the northern sperm-whale or blunt-headed cachalot. The naturalist Bosc noticed a larval cestode found in the fatty tissues surrounding the reproductive organs of *Delphinus delphis*. He called it

an hydatid (*Hydatis*), and Rudolphi placed it with the Cysticerci (*C. delphini*). According to Van Beneden the parasite in question is probably a sexually-immature example of the *Phyllobothrium delphini* described by his son. Edouard Van Beneden found this scolex in great abundance in a dolphin (*Delphinus delphis*), which he dissected at Concarneau in 1868. The sexually-mature state of this worm is, as the Belgian *savans* remark, to be looked for in some one or other of the larger sharks. The *Phyllobothrium* has also been found in the black fish, tursio, or high-finned cachalot (*Physeter tursio*). M. Gerrard Krefft has described a cestode from the stomach of a dolphin (*Delphinus Forsteri*), which he terms *Tænia Forsteri*. The strobile only measured 2½″ in length. It is just possible that the worm may be identical with the species found by Schott. Unfortunately M. Krefft did not find any ova, and his figures do not indicate the position of the reproductive pores, if, indeed, they were present. In this place, therefore, it is fitting to remark that, under the name of *Tetrabothrium triangulare*, Diesing has furnished the diagnosis of a small cestode found by Schott in *Delphinus rostratus* off the coast of Portugal. The strobile measured only two or three inches in length, and showed a uniserial disposition of the reproductive pores. Remarking on this species Van Beneden has stated that this is the only sexually-mature tapeworm hitherto encountered in the intestines of the cetacea. This observation, made in 1870, is somewhat unfortunate, because I had already, in the year 1855, described a very large and mature form of cestode (*Diphyllobothrium stemmacephalum*) from the common porpoise (*Delphinus phocæna*). As stated by me to the Linnean Society in December, 1857, the small intestine of this porpoise was completely choked for the space of eight or nine feet by fine tapeworms so closely packed together that the gut presented the appearance of a

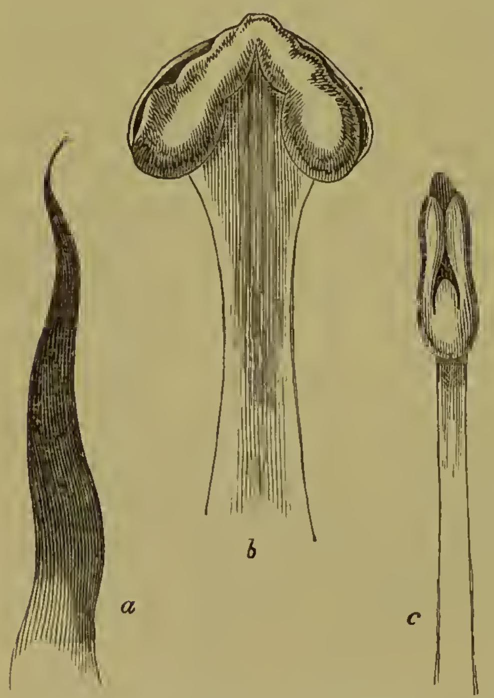

FIG. 69.—*Diphyllobothrium stemmacephalum.* *a*, Head, neck, and upper part of the strobile; *b*, front, and, *c*, profile views of the head. Enlarged. Original.

solid cylinder. The same porpoise yielded the flukes already described (*D. Campula*). As afterwards remarked in my treatise on the 'Entozoa' (1864), four of the tapeworms measured, respectively, from 7′ to 10′ in length, the fifth example being relatively small (18″ only). For a full description of the worm I must refer either to the Linnean 'Transactions' or to my introductory volume whence the figures here given are taken. Five of the finest examples of this remarkable cestode have been added to the small collection of entozoa which I prepared for the Museum of the Middlesex Hospital Medical College. The head of this large cestode is excessively minute. The same cetacean host not only yielded these new cestodes and flukes, but also great numbers of the well-known strongyloid lung-worms, called *Prosthecosacter inflexus* and *P. convolutus*. Another species (*P. minor* or *Pharurus minor*) also infests the porpoise, and a fourth (*P. alatus*) the narwhal. As I have elsewhere observed ('Entozoa,' p. 91), the three first mentioned forms are readily distinguishable from each other by their relative size and length, and also more especially by the form of the tail. The females of *P. inflexus* attain a length of nine inches, and those of *P. convolutus* may be upwards of 1½″ in length, whilst those of *P. minor* do not exceed an inch. The species described by Leuckart, from *Monodon monoceros*, is only half an inch long. All the forms infesting the porpoise were met with by Professor Quekett, and one of them has been carefully anatomised by Professor Busk. Probably several other species will be discovered when the lungs and cranial sinuses of the larger cetacea are carefully examined for this purpose. The form (*P. convolutus*) here represented is the least known of the three infesting the porpoise. This species has been dissected by Kuhn and Eschricht, whilst the other species have not only been examined by these authors, but also by Raspail, Dujardin, Von Siebold, Van Beneden, Leidy, and several other helminthologists. Some of Professor Busk's examples of the male worm (*P. convolutus*) were fully fifteen lines long, yet, from the condition of the internal reproductive organs, he was led to believe that they were not quite fully grown. I cannot here repeat the anatomical details given in my former work, but I may add that all the species of this genus reproduce viviparously. If the worms are examined in the fresh state the young may occasionally be seen escaping by the vagina. Professor Van Beneden noticed this phenomenon in *Prosthecosacter inflexus*,

and the same thing was observed by Busk in *P. convolutus.* In the instance here drawn (Fig. 71) one of the embryos is in the act of emerging, its caudal extremity being still lodged within the vulva of the parent. In the fresh worm one may also see, under the magnifying glass, numerous young worms coiled together within the oviduct; the last-named organ widening out into a capacious sac at a little distance above the end of the tail. The embryos measure about $\frac{1}{300}''$ by $\frac{1}{5000}''$ in breadth.

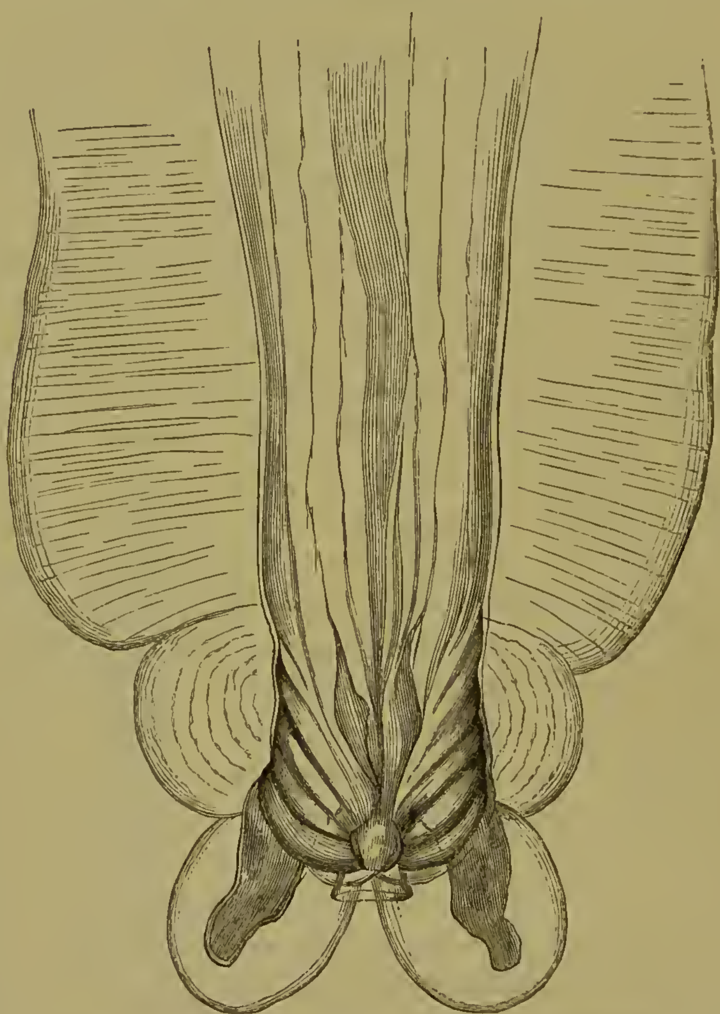

Fig. 70.—Tail of the male *Prosthecosacter convolutus.* Highly magnified. After Busk.

Higher up, within the uterine and ovarian ducts, the ova may be seen in all stages of development, according to the particular region of the tube under examination. In their full-grown condition the eggs have a longitudinal diameter of $\frac{1}{1100}''$ by a transverse measurement of about $\frac{1}{1700}''$.

As regards the development and migrations of the young worms, it is highly probable that the embryos enter the bodies of various fishes before they have acquired sexual maturity.

Thence they will be passively transferred to the stomachs of cetacea, whence they bore their way through the tissues to the bronchi and pulmonary vessels. Though usually found in these situations they also infest the cranial sinuses. *Prosthecosacter minor* is frequently lodged within the cavity of the tympanum. Professor Quekett and myself, working independently, found examples of *P. inflexus* occupying the chambers of the heart. Under the name of *Filaria inflexicaudata,* Prof. Von Siebold has described yet another pulmonary nematode from the porpoise.

FIG 71.—Tail of the female *Prosthecosacter convolutus* (magnified 60 diameters), with a section of the oviduct (magnified 220 diameters), and a separate embryo (magnified 350 diameters). After Busk.

It occupied cysts in the lung. Like the strongyloids above mentioned, the females are viviparous, but the males are destitute of any caudal hood. In the whale (*Balænoptera*) killed off the isle of Rugen, and already alluded to, M. Rosenthal obtained a large number of Filariæ (*F. crassicauda,* Creplin). To employ Dujardin's words the worms were situated " dans les corps caverneux du pénis d'une *Balæna rostrata.*" The males and females measured respectively 6½ and 13 inches in length.

Several forms of ascarides are known to infest cetaceans. The species called *Ascaris simplex* by Rudolphi was originally procured from the œsophagus and stomach of the dolphin of the Ganges and afterwards by Albers from the common porpoise. According to Diesing the worms obtained by Dussumier from a dolphin, taken off the Maldive Islands, must be referred to the same species, but Van Beneden maintains that Dussumier's "find" refers to a distinct species, which he calls *Ascaris Dussumierii.* To this view I cannot see any objection, but I think that Van Beneden's retention of Lebeck's *Ascaris delphini* as distinct from *A. simplex* is untenable. Speaking of examples of this entozoon received from Calcutta, I have remarked in the 'Zoological Society's Proceedings' that Dr John Anderson's collection of parasites showed four specimens of this species. The worms had been obtained from the intestines of *Platanista gangetica.* Singular to say, all the examples were of the female sex, the two largest measuring about $1\frac{3}{8}''$ from head to tail. The smaller worms did not exceed one inch in length. In connection with these specimens (all of which were carefully examined by me on the 28th of September, 1875) I have only to add that they presented the peculiarly flexed state of the chylous intestine described by Dujardin. As that helminthologist had accurately surmised, the *Ascaris delphini* of Rudolphi must be regarded as identical with this species. It is impossible to say how many distinct species of cetacean lumbricoid worms exist. Messrs Krefft and Masters found a species of *Ascaris* infesting a *Delphinus Forsteri* taken off Sidney, New South Wales. Creplin also, in 1851, described a species (*A. angulivalvis*) from the intestines of *Balæna rostrata.* The males are less than three inches long, the females measuring $3\frac{1}{2}''$. The late C. M. Diesing received from Prof. Steenstrup a notice of some nematodes taken from a narwhal (*Monodon monoceros*), which appeared to the Vienna authority to be scarcely different from Creplin's worm. Under the title *Conocephalus typicus* Diesing has both figured and described a remarkable nematode, two inches in length, which possesses the power of retracting its conical, or, rather, mushroom-shaped head within the body, somewhat after the manner of certain Echinorhynchi. His description is based upon museum specimens that were obtained from the stomach of a dolphin (probably *Delphinus delphis*) captured in the Atlantic Ocean. In addition to the above nematodes some few

others remain to be mentioned. Thus, the *Peritrachelius insignis* of Diesing was obtained by Natterer from the stomach of *Delphinus amazonicus* (Spix and Martius). The largest males measured $3\frac{1}{2}''$ and the females $5\frac{1}{2}''$.

Another singular parasite, named by its discoverer, Roussel de Vauzème, *Odontobius ceti*, was found by him in the mucus covering the bristles (*fanons*) of *Balæna australis*. The separate worms measured about $\frac{1}{5}''$ in length only, but they occurred in very great numbers. Lastly, Van Beneden points to certain filiform worms found by Pallas in the cavity of the ear of *Beluga leucas* as probably representing another distinct species of nematode, which he designates *Strongylus Pallasii*. I suspect, however, they will only have been fine specimens of *Prosthecosacter minor*. Be that as it may, it is as well to be reminded that Albers and Mehlis, and also Klein, Camper, and Rosenthal, found *P. minor* within the tympanic cavity of the common porpoise. When looking into the Museum stores of the Royal College of Surgeons, I found many choice examples of the genus *Prosthecosacter*. Some few were evidently Hunterian, but others had been separately contributed by Professors Owen and Quekett.

The acanthocephalous entozoa are well represented in whales. One of the commonest species is *Echinorhynchus porrigens*, of which I possess specimens given me by Prof. Goodsir, who procured them from a *Balænoptera rostrata*, captured in the Firth of Forth. The Hunterian Collection contains examples of this worm, recorded as having been obtained from *Balæna mysticetus*; and also several Echinorhynchi from the pike-whale. Professor Owen regards these last-named entozoa as distinct (*E. balanocephalus*, Owen). Probably Hunter's whale-worms, which resembled *E. fillicollis* of the eider duck, and which Van Beneden has characterised as representing a distinct species (*E. mysticeti*), were examples of *E. porrigens*. The specimens set up by me for the Museum of the Royal College of Surgeons were all of Hunterian origin. The whole subject of cetacean Echinorhynchi requires revision, and would well repay special investigation. The small, oval-shaped entozoa found by Murie in a whale which Van Beneden refers to *Balænoptera musculus* were probably examples of a distinct species of this genus (*E. Muriei*). The Vienna helminthologist has described a small species (*E. turbinella*) obtained by Hyrtl from *Hyperoodon butzkopf*. The male worms measured $\frac{1}{2}''$ in length. Another

small species (*F. pellucidus*) was discovered by Leuckart in the intestines of *Delphinus delphis*, the males measuring less than $\frac{1}{4}''$, and the females about $\frac{1}{2}$ an inch. Lastly, under the name of *Echinorhynchus brevicollis*, Van Beneden has indicated another species found by Malm in the intestines of a curious whale (*Balænoptera Sibbaldii*) captured alive off the coast of Sweden. The Louvain *savant* refers to the "take" of another example of this rare whale in the Firth of Forth about the same period. A good many whales have been captured of late years off our English and Scottish coasts, but, unfortunately, very little effort has been made to collect the numerous entozoa which they undoubtedly will have contained.

The external parasites and fellow-boarders or messmates of Cetacea are almost as numerous as helminths. In this work, however, little account can be taken of them. Every naturalist is familiar with the common *Cyamus balænarum*, and voyagers tell us that the whales are sometimes so densely covered by these lice that they impart to the skin a white color, and so enable the fishermen to see their victims at a great distance. The *Cyami* and *Caprellæ* are closely allied forms of læmodipodous crustaceans. Professor Lütken, of Copenhagen, has enumerated about a dozen distinct species of *Cyami* which are parasitic upon whales. Some of the *Pycnogonidæ* are said to attach themselves to whales. In their young state they are known to be parasitic upon polyps. I obtained specimens of these in 1856. The barnacles found on whales are genuine messmates; when once they have attached themselves to the skin, they remain permanently fixed. Like the *Cyami* or true whale-lice, these parasitic cirrhipeds are so numerous that almost every cetacean host may be said to carry its own species of louse and its own species of barnacle. The classification of these creatures is an admitted difficulty, even amongst skilled crustaceologists. The genera of cirrhipeds that are parasitic upon whales chiefly belong to the genera *Coronula, Diadema, Tubicinella,* and *Conchoderma,* but in addition to these, many lernæans of the genera *Penella* and *Lerneonema* are found on whales, and also, according to Van Beneden, at least one species of *Acarus.* This mite (*Acaridina balænarum,* Van Beneden) is found on *Balæna australis.* Here I must stop. The limits of this work preclude my attempting a more extended notice or enumeration of the crustacean and arachnidan parasites.

Notwithstanding the known differences existing between the

phytophagous manatee-dugong group and the true whales, the parasites of this remarkable order of mammals (*Sirenia*) will be most conveniently noticed in this place. Not much is known respecting them. A single species of Amphistome (*A. fabaceum*) of the usual size has been described and figured by Diesing from the cæcum and large intestine of Natterer's manatee (*Manatus exunguis*), the same mammal yielding a rather peculiar nematode, *Heterocheilus tunicatus*. This worm possesses a complicated set of cephalic lobes and oral papillæ, which at first induced Diesing to call the genus *Lobocephalus*. These structures have been fully described and figured in Diesing's account of the anatomy of the worm in the 'Annals of the Vienna Museum.' The males measure $1\frac{1}{4}''$ and the females up to $1\frac{1}{2}''$ in length. From the stomach of an Indian dugong (*Halicore*) Rüppell and several other naturalists obtained lumbricoid worms (*Ascaris halicoris*, Owen), the males of which measured $2\frac{1}{4}''$ and the females from four to five inches in length. Rüppell's specimens were from the Red Sea and Owen's from Penang. From the now extinct *Rhytina Stelleri* similar worms were obtained by Steller, who called them *Lumbrici caudidi.* Following Brandt's nomenclature the species has since been recognised as *Ascaris rhytinæ.* The worms measured half a foot in length, and occupied the stomach and duodenum. They were obtained by Steller in July, 1742, the last of the Rhytinas having been seen in 1768.

Bibliography (No. 55).—*Baird*, "Entozoa of Cete," 'Brit. Mus. Catalogue,' Index, p. 120, 1853.—*Idem*, "*Ascaris halicoris*," in 'Ann. Nat. Hist.,' 1860, p. 329; see also "Description of a rare Entozoon from the Stomach of the Dugong," 'Proc. Zool. Soc.,' 1859.—*Beneden, P. J. van*, "Les Cétacés, leurs commensaux et leurs parasites," 'Bullet. de l'Acad. Royale de Belgique,' p. 348, 1870.—*Idem*, 'Animal Parasites,' 1876.—*Beneden, E. van*, in 'Comptes Rendus,' 1868.—*Bennett, D.*, in 'Proc. Zool. Soc.,' 1837, p. 30.—*Brandt*, "*Asc. dugonis* and *A. rhytinæ*," in 'Bull. P.-Math. de l'Acad. Imp. des Sci. de St Peters,' tom. v, p. 192.—*Cobbold*, "Trematode Parasites from the Dolphins of the Ganges, *Platanista gangetica* and *Orcella brevirostris*," 'Linn. Soc. Journ.,' Zool. Div., vol. xiii, p. 35, 1876.—*Idem*, "Entozoa of *Delphinus phocæna*," 'Linn. Soc. Trans.,' vol. xvii, p. 167, 1858.—*Idem*, "Descript. of *Asc. Andersoni*," in 'Notes on Entozoa,' part iv, in 'Proc. Zool. Soc.,' March, 1876, p. 296.—*Idem*, 'Catalogue of the Speci-

mens of Entozoa in the Museum of the Royal College of Surgeons (Preps. Nos. 39-43 and 98-101),' 1866; see also Owen, for an account of the Hunterian specimens of Echinorhynchi.—*Creplin, F. C. H.*, "Note on a Filaria and a Monostoma from a Whale (*Balæna rostrata*)," from 'Nova Acta Acad. N. C.,' xiv, in 'Zool. Journ.,' 1832–34, vol. v, p. 381; and in 'Ersch. and Grube's Encyclop.,' 1846, s. 172.—*Idem*, "On *Asc. angulivalvis*," in 'Wiegmann's Archiv,' 1851, s. 158.—*Diesing*, "On *Heterocheilus* and *Amphist. fabaceum*," in 'Neue Gattungen von Binnenwürmen (u. s. w.),' 'Annalen des Wiener Museums,' 1839.—*Idem*, "Descr. of Conocephalus," in 'Revision der Nematoden' (1860), from 'Sitzungsb. d. k. Akad. d. w. math.-naturw.,' 1861, s. 669.—*Dujardin*, 'On Odontobius,' l. c., p. 292.—*Idem*, '*Ech. porrigens*,' p. 504.—*Idem*, '*Fil. crassicauda*,' p. 50.—*Idem*, 'Stenurus,' p. 266.—*Idem*, '*Asc. simplex*,' p. 220.—*Krefft*, "Parasites of Forster's Dolphin," in his 'Australian Entozoa,' from 'Trans. Etom. Soc. of New South Wales,' Sydney, 1871.—*Lebeck*, "*Asc. delphini*" (quoted by Rudolphi), Synops., p. 296, from 'Neue Schriften der Berl. Gesellsch. Naturf. Freunde,' Bd. iii, s. 282.—*Leuckart, R.*, "On Pharurus," in 'Wiegmann's Archiv,' 1848, s. 26.—*Murie*, in 'Proc. Zool. Soc.,' 1865, p. 213.—*Owen*, "*Asc. halicoris*," 'Zool. Soc. Proc.,' 1838, and in art. "Entoz.," 'Todd's Cyclop.'—*Idem*, "On Echinorhynchi," in his 'Catal. of the Contents of the Roy. Coll. Surg. Museum,' part iv, fasc. i, p. 44; and for the "External Parasites of Wales," *ibid.*, p. 74, 1830.—*Quekett, J.*, "On the Anatomy of four species of Entozoa," abstract from 'Proc. of Micros. Soc.,' in 'Ann. of Nat. Hist.,' vol. viii, 1842; also in 'Micros. Journ. and Struct. Rec.,' p. 125, and in the original series of 'Trans. of the Micros. Soc. of Lond.,' vol. i, p. 44, 1844.—*Idem*, in 'Baird's Brit. Mus. Catal. of Entoz.,' p. 3, 1853.—*Roussel de Vauzème*, "On Odontobius," 'Ann. des Sci. Nat.,' 1834, p. 326, and in 'Isis,' 1836.—*Rüppell*, "Entozoa Dugonis," in 'Abhandl. der Senkenbergschen Museums,' i, s. 106.—*Siebold, Von*, "On *Filaria inflexicaudata*,' in 'Wiegmann's Archiv,' 1842, s. 347.

Part XII (Marsupialia).

The well-known fact that, in respect of their habits, the pouched mammals epitomise, as it were, the non-marsupial quadrupeds, would naturally lead us to look for a repetition of

corresponding type-forms of entozoa as guests within their bodies. Speaking generally, the inference is correct; but very few of the entozoa hitherto found in marsupials correspond, as species, with those infesting man and non-pouched mammalia. A noteworthy exception occurs in the case of the common liver-fluke, which is abundant in the great kangaroo (*Macropus major*). This fact was well known to Bremser and all the older helminthologists, and it has since been confirmed by numerous observers resident in Australia. The late Dr Rowe, an acute observer and successful stock-breeder, who wrote chiefly in connection with the sanitary bearings of parasitism, remarked that "the native animals of Australia are much infested with internal parasites. Some of those now found in the kangaroo and the smaller marsupials may have been derived from our domestic animals; but tapeworms and other internal parasites have been met with in animals occupying regions wholly unsettled." Precisely so. That is just what we should expect. The Australian indigenous mammals have their own entozoa as a matter of course, and, in addition, they have contracted a few species from the domestic animals introduced into the country. On the whole, however, it cannot be said that the parasites of marsupials are of much practical consequence to agriculturists, since, with the exception of flukes, and probably hydatids, the Australian marsupials do not appear to harbor any entozoa that are likely to prove injurious to man and his domestic companions. The amount of fluke-germ distribution by kangaroos must be infinitesimal as compared with that proceeding from sheep and other kinds of "stock;" therefore on the score of parasitism alone it is not desirable to hasten the slaughter of kangaroos. From the scientific standpoint, it is to be regretted that the naturalists of New South Wales and other colonies have done so little towards defining the various species of marsupial entozoa. Mr Krefft, in his interesting brochure on Australian entozoa, describes a few tapeworms, and also points to several round worms which may be new to science, but with the exception of the common fluke no trematode appears to have been encountered by himself or Mr Masters in the various marsupials which they examined in the neighbourhood of Sydney and Queensland. Dr Bancroft, of Brisbane, has placed in my hands a small collection of entozoa, several of which have been obtained from marsupials, but their identification remains partly in abeyance.

Besides the liver-fluke, the only marsupial trematodes at present fairly described appear to be *Hemistoma alatum*, and two species of *Rhopalophorus* (*R. coronatus* and *R. horridus*). All of these were obtained by Natterer from the opossums of tropical America. One of these flukes was described at some length by Rudolphi, who called the species *Distoma coronatum*, and gave its length as varying from two to four lines. Diesing, in one of his best illustrated monographs, has shown that the opossums in question are infested by two distinct species of fluke, which must be generically separated from the distomes. These singular *Rhopalophori* are furnished with a pair of armed retractile proboscides (Bohrüsseln), which must form powerful organs of anchorage. The worms are found attached to the walls of the stomach and small intestines.

The tapeworms of marsupials are more numerous than flukes. Thus, we have Rudolphi's *Tænia festiva*, eight to ten inches in length, occupying the gall-bladder and hepatic duct of *Macropus giganteus*. Dr Bancroft's collection contains two almost perfect examples of a tapeworm which he procured from a small streaked kangaroo (*Halmaturus Derbyanus*). These I have identified as *T. festiva*. In this worm the reproductive papillæ, not hitherto observed, are biserially arranged. Fragments of a tapeworm (*T. didelphidis*) are preserved in the Vienna Museum, taken from the intestines of the American *Didelphis murina*. From different species of wallaby (*Halmaturus*) Mr Gerard Krefft has given more or less complete descriptions of two tapeworms (*Tænia fimbriata*, and *T. Mastersii*), and a probable Bothriocephalus (*B. marginatus*). I am not in a position to pronounce upon the distinctness of these Australian *Tæniæ*; but I may observe that Krefft's *T. fimbriata* comes very near to another species which Dr Bancroft has given me. The Brisbane *savant* obtained the worm from a koala (*Phascolarctos cinereus*). Provisionally I call this species *Tænia geophiloides*, in allusion to its general resemblance to a long millipede. The single, perfect strobile, with the head attached, measures thirteen inches in length. Prof. Leidy has furnished a description of another tapeworm (*T. bipapillosa*) from a wombat (*Phascolomys*), and Mr Krefft has described yet another species obtained from the common vulpine opossum (*Phalangista vulpina*). The single example in Krefft's possession measures four inches in length. He has named it *Tænia phalangistæ*. Some of the American opossums (*Didelphys brachyura*, and *D.*

quica) have been found to harbor a species of ligula (*L. reptans*, Diesing) in the sexually-immature state. Lastly, I find in Bancroft's collection several tapeworms obtained from that small and interesting monotreme marsupial commonly known as the Australian hedgehog, echidna, or porcupine ant-eater of the colonists (*Tachyglossus setosus*). The strobiles, which are nearly perfect, average three inches in length, and are made of very narrow and closely-set proglottides. This species is evidently new to science, and as such I propose to call it *Tænia phoptica*, in allusion to its thick-set appearance and its consequent burdensome character to the bearer. The largest proglottides measure fully $\frac{3}{8}''$ in width. There can be little doubt that the presence of any considerable number of such comparatively large tapeworms must seriously incommode, if they do not actually prove fatal to their unfortunate hosts.

So far as regards mere variety of species, the nematode fauna of marsupials is probably far in excess of that of the trematodes and cestodes. I cannot therefore do much more than enumerate the species. The Hunterian Museum of the Royal College of Surgeons contains the original "worms found alive within the capsular ligaments of the knee-joint of a kangaroo," which have been indicated as *Filariæ macropodis gigantei*. It would, in my opinion, be far better to call the worm, after its discoverer, Webster's filaria (*F. Websteri*). Dr Bancroft has likewise encountered this same parasite in the great kangaroo. From the abdominal cavity of a wallaby Leidy has also obtained a filaria (*F. spelæa*). The American opossums (*Didelphys*) are much infested by *Ascaris tentaculata*, which is found in the cæcum, and many of them also harbor a small whipworm (*Trichocephalus minutus*). Another tolerably abundant nematode (*Physaloptera turgida*) was obtained by Natterer from the stomach of *Didelphys azaræ*, *D. myosurus*, and *D. cancrivora*. The only other nematode mentioned in Diesing's 'Systema' is *Aspidocephalus scoleciformis*. This is found in *D. murina*, and *D. domestica*. From the opossum of the United States (*D. virginiana*) Prof. Leidy has also obtained *Asc. tentaculata*, *Trichocephalus minutus*, and *Physaloptera* (Spiroptera) *turgida*. According to Molin there are grounds for separating some of these stomach-worms into distinct species. Thus, he has recognised the examples found by Natterer in *Didelphys myosurus* as belonging to the genus *Histiocephalus*, as emended by himself. If the separation be allowed, then we

must add to the list Molin's *Histiocephalus subulatus.* From Bancroft's collection I am certainly in possession of two distinct kinds of nematode taken from the stomach of *Halmaturus Derbyensis.* I have also two species of nematode from *Macropus giganteus.* Their identification, however, is a matter for future consideration. Lastly, as regards the acanthocephalous parasites, only one species appears to have been described. This worm (*Echinorhynchus microcephalus*) was obtained by Olfers in Brazil, from the intestines of *Didelphus philander.* It also occurs in *D. virginiana.* Being a tolerably large species, that is to say 3″ in length, it seems surprising that it has not been found in the American opossums generally.

Bibliography (No. 56).—*Cobbold* (see Rowe).—*Diesing,* 'Syst.,' l. c., p. 519; also monogr. 'Binnenwürmen' (l. c., Bibl. No. 55).—*Kreft, G.,* 'Australian Entozoa' (l. c., Bibl. No. 55).—*Leidy,* 'Proc. Philad. Acad.,' 1856.—*Idem,* "Tape-worm from the Wombat," *ibid.,* 1875, p. 6.—*Molin,* "Una monogr. del genere Physaloptera," p. 10, "Una monogr. del gen. Dispharagus,' and 'Una monogr. del gen. Histiocephalus,' p. 37, aus dem xxxix Bd., d. 'Sitz. d. m.-nat. Cl. d. k. Akad. der Wissensch.,' s. 479-507 und s. 637-672, 1860.—*Rowe, J.,* "Parasitism in Australia" (in which the author sought to benefit stock-owners by utilising, prophylactically, my published opinions), repr. from the 'Melbourne Leader' in the 'Veterinarian,' May, 1874.—*Rudolphi* (in ref. to *Dist. coronatum*), 'Synops.,' p. 116 and 686.—*Webster* (respecting his "Filaria," see), 'Catalogue of the Hunterian Collection of Entozoa,' p. 7, prep. 49, 1866; also the old 'Catal. of the Museum Roy. Coll. Surg.' (by Owen), part iv, fasc. i, p. 37, No. 170; also Diesing's 'System,' p. 280, and Froriep's 'Notizen,' Bd. xlii, s. 328.

SECTION II.

To give an air of completeness to this treatise, I shall devote the few pages remaining at my disposal to a brief summary of the general facts of parasitism as witnessed in birds, reptiles, fishes, and evertebrated animals. For details I must refer to the separate original works and memoirs quoted in the appended bibliographies.

Part I (Aves).

A prodigious number of entozoa are known to infest birds. So far from birds being less victimised than mammals, the contrary is the case. Every now and then avian epizoötics, due to parasites, sweep off hundreds of these attractive hosts, and in some cases even nestlings are not secure from entozoal invasion. It might be supposed that predacious birds would be more liable to invasion than the graminivorous species. Such is not the case. The eagles, hawks, vultures, and owls certainly harbor a great variety of helminths, but as much may be said of the grain-feeding game birds, and still more of the water birds. Pheasants and land-fowl, grouse and partridges, are largely infested; whilst, of water-fowl, herons and plovers, rails and snipe, ducks and geese, cormorants and divers, gulls and awks, play the rôle of host to a practically infinite variety of parasitic guests. The presence of the worm-guests does not imply any previously diseased condition of the host. Shoot any water bird, say an oyster catcher (*Hœmatopus*), or, still better, a grebe (*Podiceps*), and then carefully examine its intestinal contents. You will probably find in its interior flukes and round worms, tapeworms and Echinorhynchi. Capture and examine a frog or a salamander. The result is the same, except that the cestodes would probably be absent. As for fishes, if entozoa be a proof of cachexia, then it follows that the normal condition of all piscine hosts is a diseased state. Examine any tolerably well-grown salmon, trout, pike, perch, roach, chub, carp, or barbel, and probably any one of them will contain at least three different kinds of parasites, each of which will be present in more or less considerable numbers. From what is stated above it would be obviously futile to attempt even an enumeration of the species of avian entozoa—a remark which applies almost equally to the other groups of hosts that remain for consideration. Confining our attention to a few of the more noteworthy facts, I may observe that we have no very trustworthy data respecting the power for mischief possessed by flukes. From what we know of their destructiveness in man and certain other mammals, it would be hazardous to pronounce them harmless. Scientifically, they furnish particulars of great interest. One of the most striking facts of recent study relates to Zeller's discovery that the little cercariæ (*C. exfoliata*) which are contained in a peculiar sporocyst (*Leucochloridium*

paradoxum), infesting the tentacles of a snail (*Succinea amphibia*), are in reality larval forms of a fluke (*Distoma macrostomum*) which resides in the intestinal canal of warblers (*Sylviadæ*). By experiment Dr Zeller reared the *Distoma* in question in the intestines of whitethroats (*Curruca garrula*), in blackcaps (*C. atricapilla*), and in wagtails (*Motacilla*). Six days after transference the Cercariæ acquired sexual maturity. The odd thing is, that as the sporocystic *Leucochloridia* resemble insect larvæ, they are attacked and swallowed by the birds under delusion. It is a curious example of mimetism in favour of the fluke's welfare. To this and other equally brilliant scientific results helminthologists were gradually led up by the earlier researches of Steenstrup and Van Beneden. As remarked in my 'Entozoa,' ever since Steenstrup's discovery of the fact that Cercariæ found in the bodies of water-snails were larval flukes, a peculiar interest has attached itself to this subject. Not only were the conclusions which he elicited novel in themselves, but they formed a basis for the enunciation of that interesting "law of alternate generation" with which the famous Danish naturalist's name will ever remain associated. In all essential particulars Steenstrup's statements have been verified.

By way of illustrating the phases of development through which the distomes pass I cannot do better than recapitulate in an abridged form the account I have previously given of *Distoma* (*Echinostoma*) *militare* of the snipe and curlew. This account is based on the investigations of Van Beneden, Von Siebold, and Pagenstecher. I regret that it is out of my power to reproduce the illustrations that have already appeared on this head in my introductory treatise (see 'Entozoa,' figs. 5 to 9 inclusive). Our *Echinostoma militare* produces oval-shaped eggs, which give birth to a free ciliated embryo, and this embryo produces a sporocyst or scolex by internal budding. When the sporocyst separates itself from the embryo it presents a very simple appearance, but showing already a cæcal digestive tube. The tail end is fissured, indicating an early stage of formation of caudal appendages. In the next stage we have a well-developed head and body, the tail becoming strongly pronounced. Limb-like caudal lobes project on either side, and an oral sucker makes its appearance in front. This sucker communicates with the œsophageal bulb and passes directly into the digestive cæcum, which contains a variable number of

rounded particles. At this stage, also, incompletely developed Cercariæ may be seen in the perivisceral cavity. These Cercariæ are at first shapeless organisms, but after passing through a series of gradations they ultimately assume a definite form, which, in many cases, is sufficiently distinctive to enable us to refer the Cercariæ to particular species of *Distoma*. The older writers regarded many of the cercarians as adult flukes. In the early state these larvæ are furnished with tails. They may be seen lodged within the cavity of the body of the sporocysts, being twisted and folded in various attitudes. The Cercariæ not only exhibit a cephalic and ventral sucker, but also a dark forked line representing the digestive system. At a still further stage other structures come into view, until the perfect Cercaria displays an oral sucker, a pharyngeal bulb, an œsophagus, two alimentary cæca, a ventral sucker, a water-vascular system consisting of two main excretory ducts, and a contractile vesicle, by means of which the ducts communicate with the external surface. The tail is conspicuous and furnished with a fringe. The alimentary organs conform to the general trematode type, but before passing into the sexually-mature condition other changes are undergone. The Cercariæ part with their tails, and subsequently they encyst themselves on or within the surface of the body of some mollusk. Their pupa condition is thus arrived at. The pupa itself differs from the cercaria in presenting a double crown of hooks surrounding the head, but the other organs correspond with those already described. According to Van Beneden the hooks make their appearance immediately after encystation. In this condition it is next transferred to the intestine of some higher animal, and in this final situation it gradually acquires all those organs the possession of which will entitle it to be called a sexually-mature or adult distome. In the immature fluke we may now discern the mouth, the buccal or cephalic sucker, the pharyngeal bulb, the œsophagus, the digestive cæca, the coronal spines, the contractile vesicle, the aquiferous system of vessels, the matrices of the yelk-forming glands, and also a central mass of cellules, from which all the other reproductive organs will in due time be developed. In the adult *Echinostoma militare* the upper third of the body is clothed with little spines. Taking this example as illustrative of the ordinary mode of fluke development we find that a change of hosts is necessary, and that in the intermediate state they occupy the bodies of mollusks.

Thus, for the continuation of the species, there must needs be a contemporaneity of vertebrate and evertebrate hosts. Surely no reasonable person can ascribe this concurrence to merely fortuitous circumstances. In this connection I may remark that Villot, in his account of the migrations of the trematodes, states that the cercarian forms of *Distoma leptosomum* and *D. brachysomum* of *Tringa alpina* occur in *Scrobicularia* and *Anthura*. These parasites are also found encysted in the gizzard of *Tringa*.

The tapeworms of birds are undoubtedly injurious to their bearers. All the worms appear to be armed with cephalic hooks; at least, such is the case with the species described by Krabbe, who has supplied figures of the hooks drawn to a scale. Dr Krabbe's beautiful monograph is a perfect model of its kind. In the accompanying figure the hooks have fallen (Fig. 72). On account of the frequency of their occurrence, some persons have supposed that tapeworms are not injurious to their hosts, forgetting that it is not the mere fact of the existence of tapeworms, but their excessive numbers during particular seasons that give rise to avian epizoötics. The same rule holds good with other parasites. Of course, in fledgelings, as also obtains in yearlings amongst our domesticated animals, a very few parasites are sufficient to prove destructive to the bearer. Thus, as regards the so-called "grouse-disease," during one season it may be due to tapeworms, during another to strongyles, during a third to excessive abundance of both these parasites. Unfortunately, other avian epizoötics, not necessarily due to parasites of any kind, may be mistaken for helminthic epizoöty. The same thing happens amongst quadrupeds. We have, for example, parasitic equine epizoötic outbreaks, and likewise non-helminthic equine epidemics (as in the case of the Egyptian horse plague of 1876). The true nature of any epizoöty can

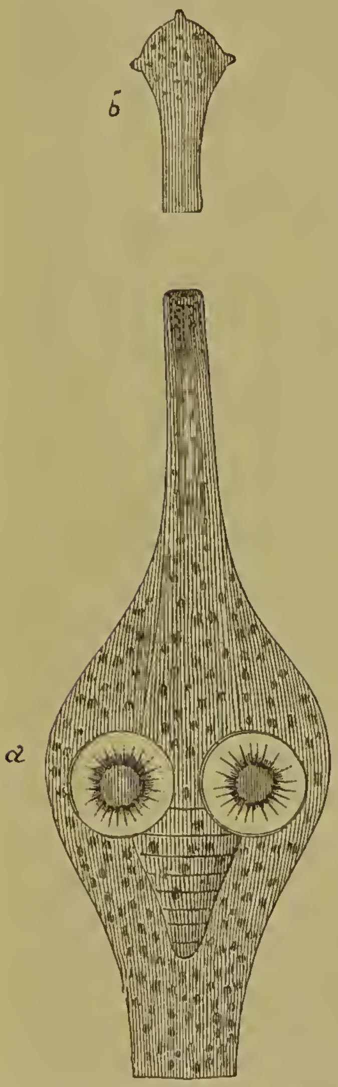

FIG. 72.—Head of *Tænia paradoxa*. *a*, Proboscis retracted; *b*, end of the rostellum expanded. Highly magnified. From an oyster-catcher (*Hæmatopus ostralegus*). Original.

only be determined by competent investigation. That was well shown in the grouse epidemic of 1872. In that epizoöty the greater number of the birds succumbed to the injuries produced by a nematode worm (*Strongylus pergracilis*, Fig. 73),

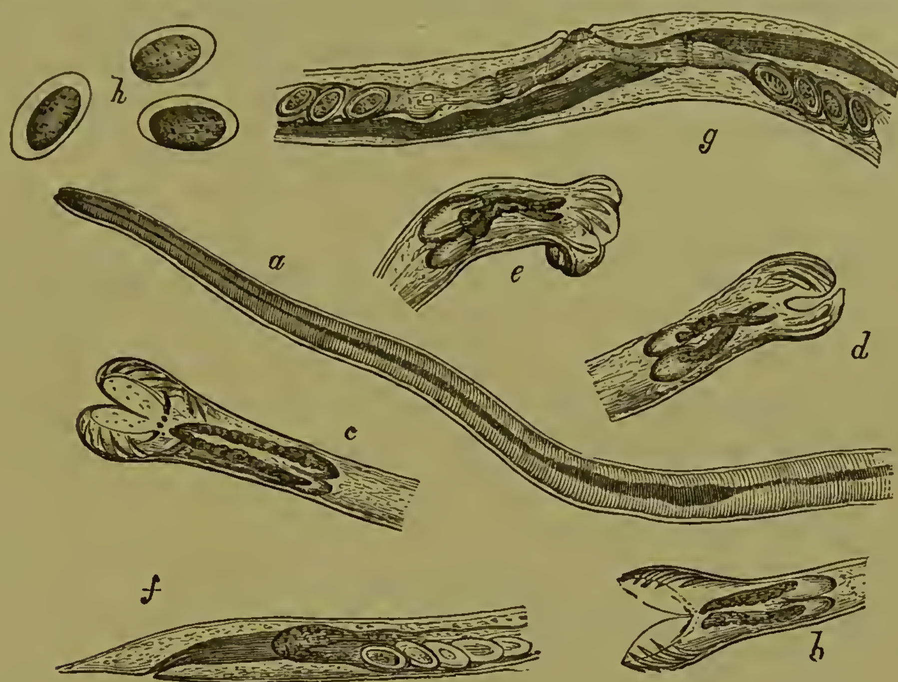

Fig. 73.—*Strongylus pergracilis*. *a*, Head and neck; *b*, *c*. *d*, *e*, tail of the male in various positions; *f*, tail of the female; *g*, section showing termination of the oviducts; *h*, three eggs. Highly magnified. Original.

but, without doubt, the occasional presence of numerous tapeworms (*Tænia calva*) hastened the consequent fatality. The following table, giving the results of examination of twelve diseased grouse from the Earl of Cawdor's estate, will show how inconspicuous a part tapeworms played in the epidemic of 1872. For further details I must refer to my brochure on the 'Grouse Disease,' and to some other memoirs quoted in the bibliography below.

No. of specimen.	Condition of bird.	State of viscera.	Tapeworms present.	Strongyles present.
1	Good	Full	None	Abundant.
2	Emaciated	Putrid	Two	Very numerous.
3	Good	Full	None	Abundant.
4	„	„	„	„
5	„	„	One	„
6	„	Shrunken	Two	Very numerous.
7	Emaciated	Much shrunken	None	„
8	Thin	Shrunken	„	„
9	„	„	„	„
10	Emaciated	Distended	Many	„
11	Thin	Rather full	Several	Abundant.
12	„	„	None	Very numerous.

I have said that tapeworms prove fatal to young birds, even to nestlings. A notable instance of this is recorded by Mr Eames. The parasites were examples of *Tænia angulata.* Apart from the epidemiological aspects of the subject, it is not uninstructive to notice the variety of helminths that infest the common fowl and game birds. Accordingly, I append a similar but more extended list than that previously given in the supplement to my introductory treatise:

Entozoa of game birds and the common fowl.	Common fowl.	Pheasant.	Caper-caille.	Black Grouse.	Red Grouse.	Grey Partridge.	Red Partridge.	Quail.
Monostoma verrucosum, Zeder...	*							
Distoma oxycephalum, Rudolphi.	*							
„ *ovatum*, Rudolphi	*							
„ *lineare*, Zeder	*							
„ *dilatatum*, Miram	*							
„ *fuscatum*, Rudolphi......	...	...	...	...	...	...	...	*
Filaria Mansoni, Cobbold	*							
Ascaris vesicularis, Froelich ...	*	*	*	...	*	*	...	*
„ *gibbosa*, Rudolphi	*							
„ *inflexa*, Rudolphi	*	...	*					
„ *compar*, Schrank	...	...	...	*	*	*	...	*
Spiroptera hamulosa, Diesing ...	*							
„ *helicina*, Molin	...	...	...	...	...	...	*	
Dispharagus nasutus, Dujardin .	*							
„ *spiralis*, Molin......	*							
Strongylus pergracilis, Cobbold	...	...	...	...	*			
Sclerostoma syngamus, Diesing .	*	*	...	...	...	*		
Trichosoma longicolle, Rudolphi	...	*	*	*	...	*		
Tænia malleus, Goeze................	*							
„ *microps*, Diesing............	...	...	*	*				
„ *exilis*, Dujardin	*							
„ *calva*, Baird	...	...	...	...	*			
„ *linea*, Goeze...................	...	...	...	...	*	*	...	*
„ *infundibuliformis*, Goeze .	*	*						
Ligula reptans, Diesing	...	...	*					

In regard to this list I can only afford space to remark that several of the species are possibly mere varieties. Some of the worms are of great interest. It occasionally happens that *Distoma ovatum* is found in the albumen of the fowl's egg, and it is even more common to obtain *Ascaris inflexa* from the same situation. For a recent example I am indebted to Dr Walker, of Peterborough. *Spiroptera helicina* resides in the feet, occasioning enlargement of the joints and consequent distress to the bearer. Probably the most important in the list is my *Strongylus pergracilis.* Here I may mention that on the 10th of April, 1878, I received a letter from Dr Manson, of Amoy,

announcing his acquaintance with a filaria infesting the eye of the fowl. On the 9th of May I also received from Dr Manson the head of a bird showing examples of the worm. As the species is new to science I have proposed to call it *Filaria Mansoni*, after the discoverer. The male is $\frac{5}{8}''$ and the female $\frac{3}{4}''$ in length. Of the injurious nematodes, giving rise to avian epizoöty, probably one of the most destructive is *Ascaris maculosa* infesting pigeons. On the 9th of October, 1873, I received a letter from Dr J. Alexander Macdonald, of Woburn, Bedfordshire, stating that he had forwarded to me a pigeon which had been found dead on the previous morning. It seems that the owner of the bird had erected a large pigeon-house, and had imported a number of Antwerp smerles, these birds all continuing in a perfect state of health until about a week before the above-mentioned date, when, to use Dr Macdonald's words "first one and then another was attacked, and so on, until four or five of the pigeons had died after a few hours' illness." The suddenness of these attacks not unnaturally suggested poisoning; and, accordingly, says my informant, the owner "had the curiosity to open one of the birds, when, to his astonishment, he found the intestines stuffed with worms." Two days later I received a letter from Dr Macdonald, stating that several others of the flock had died, and it further appeared to him probable that the daily list of sick and dying would continue to increase. On the 14th of the month three more of the birds were dead. On the 4th of the following November, the same correspondent obligingly informed me that the epidemic had been "at last mastered." It seems that altogether twelve birds had perished. On the 9th of October one of the birds was carefully examined by me, and the results were so interesting that I am constrained to give a few of the particulars originally communicated to the Zoological Society. As stated in my paper, the whole intestinal tract of the dead bird was crowded with these ascarides. The small intestine was inflamed throughout, and showed several large ulcerated patches; nevertheless, there were no traces of emaciation. From this it was evident that the parasites had grown quickly, the malady having a correspondingly rapid formation. The distribution of the parasites was curious. One specimen, two inches long, reached from the crop to the proventriculus. The cavities of this organ and of the gizzard were crammed with worms completely blocking the passage. Three of the worms had also

placed themselves within the pyloric opening, their bodies partly lodging within the duodenum. The duodenum itself was crowded with worms, their numbers somewhat decreasing downwards. I removed thirty-six worms from the œsophagus, proventriculus, and stomach, besides 166 others from the intestinal canal, thus obtaining a total of no less than 202 nematodes from this small host. Considering the large size of these entozoa, the extent of infection must be pronounced remarkable. The largest females measured $2\frac{1}{2}''$ in length. One of the most interesting facts—serving to exemplify a well-known habit of lumbricoid worms generally—consisted in the circumstance that two of the parasites had succeeded in perforating the horny lining membrane of the gizzard. The injuries had been accomplished during the life of the host, for the walls of the gizzard were inflamed opposite the perforations. There was a little half-digested food within the stomach, the *débris* of which, when placed under the microscope, showed several ova. There were no free embryos, neither had the development of the freed eggs proceeded beyond yelk-segmentation. Free eggs were also found both in the small and large intestine. The eggs measured about $\frac{1}{360}''$ by $\frac{1}{700}''$ in diameter. Referring to my paper for further anatomical details, I can only add that, despite these facts, the ascarides in question do not appear to be a very frequent source of epizoöty. It was remarked by Dujardin that Heister, at Rostok, and Gebauer, at Breslau, found this parasite abundant at the beginning of the eighteenth century; but, according to examinations conducted at Vienna, the worm was found in the common pigeon in only eleven instances out of 245, and thrice only in thirty-eight examples of the ring-dove; moreover, the examination of eighty-seven other pigeons and doves of different species yielded entirely negative results. The Dublin helminthologist, Bellingham, noticed the occurrence of this parasite in Ireland.

Fig. 74.—Tail of the male *Ascaris vesicularis*. From a ring-necked pheasant. Original.

Any attempt so much as to enumerate the species of nematoids infesting birds would carry me far beyond the aim and scope of this treatise. One of the commonest species is *Ascaris (Heterakis) vesicularis*. Many hundreds of forms have been described by Dujardin, Diesing, Molin, Krabbe, and other systematists,

and it remains for some future laborer to condense the facts which are dispersed throughout a very wide-spread literature. As regards the particular species of nematoids that are either actually known or conjectured to be injurious to birds I can only find space to repeat some of the particulars which I have elsewhere recorded in respect of *Sclerostoma syngamus.* In 1799 a letter from Dr Wiesenthal, of Baltimore, U.S., was published in the 'Medical and Physical Journal,' containing an account of a parasite infesting the trachea of fowls and turkeys in America. The communication is dated May 21st, 1797, and is the first public record concerning the entozoon. Dr Wiesenthal says: "There is a disease prevalent among the gallinaceous poultry in this country, called the *gapes,* which destroys eight-tenths of our fowls in many parts, and takes place in the greatest degree among the young turkeys and chickens bred upon old-established farms. Chicks and poults, in a few days after they are hatched, are found frequently to open their mouths wide and gasp for breath, at the same time frequently sneezing and attempting to swallow. At first the affection is slight, but gradually becomes more and more oppressive, and it ultimately destroys. Very few recover; they languish, grow dispirited, droop, and die. It is generally known that these symptoms are occasioned by worms in the trachea. I have seen the whole [windpipe] completely filled with these worms, and have been astonished at the animals being capable of respiration under such circumstances."

Any one who has witnessed the *gapes* will at once recognise the accuracy of Wiesenthal's description; and so far as the phenomena of the disease are concerned, very little more has been added in the numerous accounts which have since appeared. On the 1st of August, 1808, the English naturalist, George Montagu, communicated to the Wernerian Society a paper entitled "Account of a species of *Fasciola* which infests the trachea of poultry, with a mode of cure." Montagu does not appear to have been aware of the existence of any previous record. He gave a scientific description of the parasite, which led to its being noticed in the systematic works of Rudolphi, Dujardin, and Diesing, but the best accounts of the worm are due to Von Siebold. *Sclerostoma syngamus* has been found in the trachea of the turkey, domestic cock, pheasant, partridge, black stork, magpie, hooded crow, green woodpecker, starling, and swift. In July, 1860, I obtained a fowl suffering from the gapes, and operated upon it in the

following manner:—A small portion of wool having been dipped in chloroform and placed in front of the nostrils the bird soon became insensible. The skin of the neck was then divided and the trachea slit up to the extent of a quarter of an inch. With a pair of common dissecting forceps, I removed seven Sclerostomata. Six of these parasites were sexually united, the odd worm being a female. After I had closed the external wound with a single thread the bird woke out of its artificial sleep, when it soon recovered its legs, and ran about the table vigorously. Moreover, in a very few minutes it devoured the contents of a saucer partly filled with bread and milk. An occasional gape was caused by an accumulation of frothy mucus within the injured trachea, but this obstruction the bird soon got rid of by shakes of the head and sneezing. The only subsequent inconvenience to the bird arose from emphysematous distension of the cellular tissue of the head and neck. This was relieved by puncture, the emphysema ceasing to form after the external wound had healed. Some months afterwards I destroyed the bird, and on dissecting the neck, a distinct cicatrix was found indicating the site of the operation on the trachea. The divided cartilaginous rings, six in number, were united only by a thin layer of connective tissue. The female worms gave an average length of $\frac{5}{8}''$, the males scarcely exceeding $\frac{1}{3}''$. The mouth is furnished with six prominent chitinous lips. In both sexes the surface of the body is quite smooth, but the tail of the female exhibits a tendency to fold upon itself. The lower part of the body suddenly contracts to form a short, narrow, mucronate, pointed tail. The male is usually found rigidly affixed by means of a strong, membranous, sucker-like bursa, which proceeds from the lower end of its body. In regard to the peculiar mode of union of the sexes, it becomes an interesting point to ascertain whether there be an actual incorporation of the substance of the copulatory organs during or after the act of impregnation. In my specimens none of the three pairs were organically united, and I succeeded in separating one pair very readily. Dujardin speaks of them as being soldered together, whilst the statements of Von Siebold are still more explicit. In connection with this subject the latter observer makes the following comment ('Wiegmann's Archiv,' 1836, s. 106):—"The two sexes of almost all round worms are united only at the time of copulation. The male of *Heteroura androphora* has also the habit of remaining connected

with its mate beyond the period of copulation; here, thus, there is a continuous union of the sexes without a growing together; and in *Syngamus trachealis* there is ultimately a lasting continuity of the sexes by means of an actual growing together." Having confidence in Von Siebold's statement, I concluded that the sexual union in my specimens had only recently been effected. Admitting this to have been the case, one naturally asks how the mature eggs can make their escape. Clearly, the eggs can only escape by an eventual breaking up of the body of the parent. The eggs of *Sclerostoma syngamus* are comparatively large, measuring $\frac{1}{250}''$ in length. Many of the ova contained fully formed embryos, and in the centre of the lower third of the body of one of them I perceived an undulating, imperfectly formed intestinal tube. By whatever mode the young escape the shell, it is clear that they are already sufficiently developed to undertake an active migration. A change of hosts is probably necessary, but in the first instance they either enter the substance of fungi or other vegetable matters, or they bury themselves in the soil at a short distance from the surface. In view of checking the destructive influences of this parasite, the following methods have been recommended.

First. The simplest plan consists, as Dr Wiesenthal long ago pointed out, in stripping a feather from the tube to near the narrow end of the shaft, leaving only a few uninjured webs at the tip. The bird being secured, the webbed extremity of the feather is introduced into the windpipe. It is then twisted round a few times and withdrawn, when the worms are found attached. In some instances this plan succeeds entirely.

Secondly. The above method is rendered more effectual when the feather is previously steeped in some medicated solution which will destroy the worms. Mr Bartlett employs salt for this purpose, or a weak infusion of tobacco; and he informs me that the simple application of turpentine to the throat externally is sufficient to kill the worms. It should be borne in mind that the bird itself may be injuriously affected by these drugs if they are carelessly employed.

Thirdly. The treatment recommended by Mr Montagu proved successful in his hands, although the infested birds were old partridges. One of his birds had died of suffocation; but he tells us that "change of food and change of place, together with the infusion of rue and garlic, instead of plain water, to drink, and chiefly hemp-seed, independent of the green vege-

tables which the grass plot of the menagerie afforded, recovered the others in a very short time."

Fourthly. The plan I employed in my experiment. This is only desirable in advanced cases, where suffocation is impending. It will afford instant relief, as the trachea may be cleared of all parasitic obstructions.

Lastly. The essential point to be observed is the total destruction of the worms. This will help to put a stop to future epizoöties. If the parasites are merely killed and thrown away carelessly, the eggs will sustain no injury. Decomposition having set in, the young embryos will sooner or later escape their shells, migrate in the soil or elsewhere, and ultimately find their way into the air-passages of birds in the same manner as their parents did before them.

In this place I must not omit to mention the remarkable circumstance, quoted in my pamphlet on the grouse disease, that Prof. Wyman, of Boston, found *Eustrongyli* surrounding the cerebellum in seventeen out of nineteen snake-birds or water-turkeys that had been shot in Florida. These viviparous nematodes apparently occasion their avian bearers no inconvenience. No doubt, as Wyman observes, their presence must be regarded as a normal state of things : but should they occur in excessive numbers, then we can hardly doubt the result.

As regards acanthocephalous parasites, although not so numerous as the nematodes, it is extremely probable that they play a similar rôle. Parasites which prove fatal to swine are scarcely likely to be harmless in birds. On the 18th of February, 1875, I received from Sir Joseph Hooker eleven worms for identification. Mr Charles P. Hooker, his son, subsequently informed me by letter that he had found them in a Redwing (*Turdus iliacus*) which he dissected in January, 1875. The worms (*Echinorhynchus transversus*) occupied the large intestine, probably to the number of one hundred in all. Hitherto this parasite has been found abundantly in the blackbird, thrush, and in most of the *Turdidæ ;* but not in the redwing. It has also been obtained from the starling and redbreast. The presence of so many of these armed parasites in one small host could hardly fail to inflict severe injury on the bearer.

In concluding this section of my work I can only find space to make a few acknowledgments. Most of the rare, new, or interesting avian entozoa which I have examined and described

have been received either from the Zoological Gardens, or from personal friends. In particular I may mention the collections sent to me by Mr Charles Darwin, Mr Robert Swinhoe, Mr Charles W. Devis, Dr Murie, Dr John Anderson, and Mr Spooner Hart, of Calcutta. A great many correspondents have contributed single specimens, many of which I have already incidentally acknowledged in these pages. In this place I must particularise the new species (*Ascaris Cornelyi*) which I described from specimens sent to Mr Sclater. This worm infests the vulturine pintado (*Numida vulturina*). Mr Darwin's collection contained fine examples of *Filaria horrida* from the American ostrich (*Rhea*). When dissecting birds at the Zoological Society's Menagerie, I obtained (in addition to the parasites already mentioned) *Distoma æquale* from the American owl (*Strix perlata*); *Tænia multiformis* from the night heron (*Ardea nyctocorax*); *T. infundibuliformis* from a horned pheasant (*Phasianus*); *T. lævis* and *T. lanceolata* and also *Ascaris tribothrioides* from a dusky duck (*Anas obscura*); *Eustrongylus papillosus* (fig. 75) from the larus crane (*Grus antigone*); *Trichosoma longicolle* from the horned pheasant, and *T. brevicolle* from the Sandwich Island goose (*Bernicla Sandwichensis*). This bird was also infested by *Spiroptera crassicauda* and *Ascaris dispar*. From the ring-necked pheasant (*Ph. torquatus*) and from the black-backed Kaleege (*Euplocomus melanotus*), and also from a cheer pheasant (*Ph. Wallichii*), I obtained abundance of *Ascaris vesicularis*. From the ashy-headed goose (*Chloephaga poliocephala*) examples of *Str. tubifex* and *Str. nodularis*. This bird also yielded a new species (*Str. acuticudatus*). From a tinamou (*Tinamus*) I obtained the *Ascaris strongylina* of Rudolphi (*Str. spiculatus*, mihi). From amongst our British birds I have obtained *Asc. depressa*, *Trichosoma falconum* and *Hemistoma spathulum*, from the kite (*Falco milvus*). Of these three worms, the last named was also found in the long-eared owl (*Strix otus*), whilst the first likewise occurred in a kestrel (*Falco tinnunculus*) and in a honey buzzard (*Pernis apivorus*). I may add *Filaria attenuata* from a peregrine (*F. peregrinus*); and *F. leptoptera* from a sparrow hawk (*Accipiter nisus*). From the redshank (*Totanus calidris*) I obtained *Tænia variabilis*, and from the curlew (*Numenius arcuata*) *T. sphærophora*; and from various gulls (*Larus glaucus*

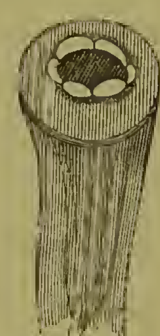

FIG. 75.—Head of *Eustrongylus papillosus*. Magnified. Original.

and *L. tridactylus*) the *Tetrabothrium cylindraceum.* Also from the grey gull *Echinostoma spinulosum.* From the red-throated diver I procured *Tetr. macrocephalum.* I found this tapeworm also in the guillemot (*Uria troile*), together with a nematode (*Ascaris spiculigera*) two examples of which were lodged in the right auricle of the heart. From a capercaillie (*Tetrao urogallus*) I have obtained a species of *Ligula,* and likewise numerous examples of *Trichosoma longicolle.* Of necessity, this brief notice only comprises a small part of the avian entozoa contained in my collection, many of which I have not had time to describe, whilst, as regards others, I can only say that they remain in abeyance for examination and identification.

Mr Brotherston has recently recorded an interesting find (made Nov. 25th, 1874) of nematodes in the legs of the lesser grebe (*Podiceps minor*), and also (Feb. 27th, 1878) in the water-hen (*Gallinula chloropus*). Both limbs of both birds were infested. The worms of the grebe were spirally coiled amongst the muscles and tendons near the lower end of the tibia, and when unrolled measured about an inch in length. The parasites of the waterhen were similar in appearance. Not improbably these were all sexually-imperfect female examples of *Filaria acuta* hitherto found in the abdomen of grebes.

The British Museum contains many interesting specimens purchased from the collection of Von Siebold, but they are practically inaccessible to investigators. The entozoa in the Hunterian Collection, though few in number, are in an excellent state of preservation, and at all times accessible to visitors.

The ectozoa of birds are too numerous to be dealt with in these pages. References to recent papers by Haller, Mégnin, and Westwood will be found below. The insects infesting the domestic fowl have been alluded to in connection with the occurrence of poultry-lousiness in the horse.

Bibliography (No. 57).—(Anonymous), "On the (gape) Diseases of Fowls," the 'Veterinarian,' p. 267, 1841.—(Anon., initialed "Q."), Letter on the "Grouse Disease," in the 'Times,' Sept. 5, 1874.—(Anon.), "On Grouse and Partridge Disease," being annotations in the 'Lancet,' Sept. 4, 1875, pp. 360 and 361.—(Anon.), "Grouse Disease," letter signed "R." (probably from Lord Ravensworth), in 'Land and Water,' Aug. 16, 1873. —(Anon.), "Grouse Disease," article (from "W. C.") in the 'Field,' Aug. 2, 1873 (criticising my brochure.—T. S. C.).—

Arlong, "Note on Tænia from the Fowl," 'Rec. Méd. Vét.,' 1875.—*Baird, W.*, "Descr. of *Tænia calva* from the Grouse," in 'Brit. Mus. Catalogue,' p. 83.—*Blavette*, "Descr. of a Verminous Disease among Fowls," 'Veterinarian,' p. 649, 1840. —*Brotherston, A.*, "Parasitic Worms in Legs of Grebe (*Podiceps minor*) and Water-hen (*Gallinula chloropus*)," 'Science Gossip' for April, 1878, p. 88, and in 'Proceedings of the Berwickshire Naturalists' Club,' vol. viii, p. 288.—*Carter, B.* (see Cobbold). —*Chapman, H. C.*, "Description of a new Tapeworm from Rhea," 'Proceed. Phil. Acad.,' 1876, p. 14.—*Chatin, J.*, "Étude sur des helminthes nouveaux ou peu connus (treating of a Cyathostoma, from *Anas tadorna* and *Sclerostoma pelecani*)," 'Annales des Sciences Naturelles,' 1875.—*Cobbold*, 'The Grouse Disease, a statement of facts tending to prove the Parasitic Origin of the Epidemic,' London, 1874.—*Idem*, Letter in the 'Field,' Sept. 9, 1872.—*Idem*, "Contributions to our Knowledge of the Grouse Disease, with description of a new Species of Entozoon," 'Veterinarian,' March, 1873; see also an article (by Brudenell Carter) in the 'Times' for Sept. 5, 1874; repr. in the 'Veter.,' Oct., 1874.—*Idem*, "Remarks on the Entozoa of the Common Fowl and of Game-birds, especially in relation to the Grouse Disease," the 'Field,' Sept. 14, 1867, and 'Brit. Assoc. Rep.,' 1867.—*Idem*, "On Sclerostoma and the Disease it occasions in Birds," 'Linn. Soc. Proc.,' 1861; repr. in the 'Field,' June 22, 1861, and in 'Edin. Vet. Rev.,' vol. iii, p. 439, 1861, also in Tegetmeier's work on 'Poultry;' see also a comment on "Gapes," by "Umbra," in the 'Field,' June 29, 1861.—*Idem*, "Parasites from the Zoological Gardens," 'Intellectual Observer,' 1862.—*Idem*, "Notes on Entozoa (species Nos. 1, 7, 9, 12)," in 'Zool. Soc. Proc.,' 1873–76.—*Idem*, 'Linn. Soc. Trans.,' 1858.—*Idem*, "On Entozoa of Birds and Fishes, collected by Mr Charles W. Devis," 'Zool. Soc. Proc.,' 1865.—*Idem*, "Note on Entozoa in the Crested Grebe," the 'Field,' March 29, 1873.—*Colquhoun, W.*, 'Remarks on the decrease of Grouse, and on the Grouse Disease (Gapes),' Edinburgh, 1858; see also a notice in 'Edin. Vet. Rev.,' vol. i, April, 1859.—*Crisp, E.*, "Note on Hydatids in an old Honduras Turkey," 'Path. Soc. Trans.,' 1863.—*Idem*, "On Sclerostoma," 'Rep. of Path. Soc.,' in 'Med. Times and Gaz.,' Oct. 26, 1876, p. 474.—*Idem*, "Note on Filaria in the Heart of a Peregrine Falcon," 'Path. Soc. Trans.,' 1854.—*Davaine*, 'Syngame de la trachée,' p. 37, and 'Synops.' cxiv, in his 'Traité.'—*Devis, C. W.*

(see Cobbold).—*Diesing,* 'Revis. der Myzelminthen,' Abtheil. "Trémat.," 1858.—*Idem,* "Tapeworm from Podiceps," in his 'Zwanzig Arten von Cephalocotyleen,' Wien, 1856.—*Idem,* see various species in his 'Revisionen,' given in Bibl. No. 58.—*Eames, C. J. L.,* "On Tapeworm in Blackbirds," letter to the 'Lancet,' June 9, 1877, p. 863.—*Farquharson, R.,* "The Grouse Disease (due to a contagious fever)," letter to the 'Lancet,' Sept., 1874.—*Fergusson, J.,* "On Grouse Disease," letter in the 'Times,' July 16, 1878.—*Gentles, T. W.,* "Tapeworm in Birds," letter to the 'Lancet,' Jan. 18, 1868, p. 106.—*Haller, G.,* "Freyana und Picobia, zwei neue Milbengattungen," in 'Sieb. u. Köll. Zeitsch.,' 1877, s. 181.—*Johnston, D.,* "On the Grouse Disease," letter in the 'Lancet,' Sept. 20, 1873, p. 441.—*Krabbe,* 'Bidrag til Kundskab om Fuglenes Bændelorme,' Copenhagen, 1869 (contains a summary in French, 'Recherches sur les Ténias des Oiseaux').—*Linstow, O. von,* "Enthelminthologica" (containing descriptions and notes on worms from birds, fishes, reptiles, and mollusks), 'Archiv für Naturgeschichte,' 1877.—*Idem,* "New Flukes (*Dist. vitellatum* and *D. macrophallus*) from *Totanus hypoleucus,* and *D. cælebs* from Fringilla," Beobacht. in 'Arch. f. Naturg.,' 1875, s. 189–193.—*Maclagan,* "Note on the Grouse Disease," 'Proc. Roy. Soc. of Edin.,' April 20, 1874, p. 378.—*Marion,* "Révis. des Némat. du Golfe de Marseilles," 'Compt. Rendus,' 1875.—*Mégnin, P.,* "On Harpirhynchus and other Mites," in 'Rev. f. Thierheilk.,' Oct., 1878, s. 146.—*Idem,* "Mémoire sur les Cheylétides Parasites (Picobia, &c.)," 'Journ. d'Anat. et de Physiol.,' 1878; see also 'Rev. f. Thierhielk.,' Sept., 1878 *et seq.*—*Molin,* in his various monographs (quoted in Bibl. Nos. 54, 56, and elsewhere).—*Montagu, G.,* "Account of a species of Fasciola which infests the Trachea of Poultry, with a mode of Cure," 'Memoirs of the Wernerian Nat. Hist. Soc.,' vol. i, p. 194, 1811.—*Perrier,* 'On Syngamus' (brochure, Paris, 1875).—*Pulteney, R.,* "On Ascarides discovered in *Pelicanus carbo* and *P. cristatus,*" 'Linn. Trans.,' vol. v, 1800, p. 24.—*Röll,* "Beitrag. zur Entwickelungsgeschichte der Tænien," 'Verh. d. Würzb. p. m. Ges.,' Bd. iii, 1852, s. 51.—*Sanderson, J. B.,* "On Grouse Disease," 'Brit. Med. Journ.,' May 15, 1875.—*Small, M.,* "Worms in the Eyes of Geese," from the 'Irish Farmer's Gaz.,' in the 'Veterinarian,' 1862, p. 19.—*Tait, L.,* "Tapeworm in Birds," letters to the 'Lancet' for Jan. 25, 1868, p. 145, and Feb. 8, 1868, p. 214; see also "Pediculus," *ibid.,* p. 180.—

Tegetmeier, "On the Grouse Disease," in the 'Field,' Sept. 12, 1874.—*Thick*, "Letter on the Cure of Gapes," in 'Land and Water,' Aug., 1867, p. 77.—*Vaughan*, "The Grouse Disease," in the 'Field,' Aug. 23, 1873.—*Villow, A.*, "Sur les migrations, et les Métamorphoses des Trematodes," 'Comptes Rendus,' 1875, and 'Ann. Nat. Hist.,' 1875 (chiefly on flukes of the sea-lark, *Tringa alpina*).—*Idem*, "Sur le syst. nerveau," &c., *ibid.*, 1875.—*Idem*, "On the Helm. Fauna of the Coast of Brittany (chiefly from birds)," 'Ann. Nat. Hist.,' from 'Comp. Rend.,' 1875, p. 1098, and from 'Arch. de Zool. Expérim. et gén.,' 1875.—*Idem*, "Sur l'appareil des Trematodes (*Dist. insigne*)," 'Compt. Rend.,' 1875.—*Wedl, K.*, 'Anatomische Beobachtungen ueber Trematoden,' Wien, 1858 (contains excellent descriptions of numerous flukes, chiefly from birds).—*Westwood, J. O.*, "New Flea on a Fowl (Sarcopsillus)," 'Entom. Month. Mag.,' xi, p. 246, 1875.—*Wiesenthal, A.*, "Account of a Parasite infesting the Trachea of Fowls and Turkeys in America," 'Med. and Phys. Journ.,' vol. ii, p. 204, 1799.—*Wyman*, "On Eustrongyli within the Cranium of Water-Turkeys," 'Proc. Boston Nat. Hist. Soc.,' 1868.—*Youatt*, "On a Verminous Disease in Poultry" (being a letter to him), 'Veterinarian,' p. 648, 1840. —*Zeller*, "On Leucochloridium," from 'Zeitsch. f. wissensch. Zool.,' 1874, s. 564, and from 'Bibl. Univ. Bullet. Sci.,' 1874, p. 366, in 'Ann. Nat. Hist.,' Feb., 1875.

Part II (Reptilia).

Much that I have advanced in respect of the parasitism of birds holds good in the case of reptiles. I cannot recapitulate. The saurians, ophidians, and chelonians are extensively infested, but in this respect the amphibian frogs, toads, and salamanders are probably the most victimised. If, on the one hand, comparatively few tapeworms have been found in reptiles, it may, on the other hand, be said that the Echinorhynchi come into prominence, causing serious injury to reptilian hosts. Serpents and chameleons are particularly liable to have their lungs infested by acanthocephalous entozoa, these organs being also attacked by pentastomes. I have received evidence of fatal epizoöty amongst chameleons from this source; and I have been requested to suggest a remedy. To prevent outbreaks of entozoal disease is one thing; to offer a radical cure when the

parasites are firmly anchored within the pulmonary organs is quite another matter.

As remarked in my 'Entozoa,' the trematodes display a great partiality for batrachians, more than half a dozen different species of fluke being known to infest the common frog. Flukes are likewise tolerably abundant in the saurian and chelonian reptiles. I regret that I cannot find space so much as to enumerate the species. As one would naturally expect, the frog has been exhaustively anatomised and examined for entozoa, and it was this creature that supplied Leuckart and Mecznikow with the materials which led to their well-known discovery and controversy respecting the development, dimorphism, and parthenogenetic phenomena exhibited by *Ascaris nigrovenosa*. I cannot give the facts in detail. Female examples of the worm live in the lungs of the frog. Their young, as embryos, pass into the damp earth and mud, where they grow up into sexually-mature forms different from the parent worms found in the frog. These free adult worms, male and female, produce rhabditiform embryos which present characters of their own and attain a certain stage of growth. At this stage they are conveyed into the lungs of the frog where they arrive at sexual maturity. As there are no male worms in the frog, it is probable that the embryos of these parasitic females are agamogenetically produced by internal budding, the sexual influence of the free males being, as it were, continued onward without actual contact with the parasitic females. Amongst the interesting parasites of the frog one must also mention *Amphistoma subclavatum* and *Polystoma intergerrimum*. The former worm resides in the large intestine and the latter in the urinary bladder. The larvæ (*Cercaria diplocotylea*) of this amphistome reside in or upon the body of water-snails, and, like the cercarian larvæ of polystoma, they are furnished with eyes. I state this fact on the authority of Pagenstecher; and, since I cannot devote a special section to the entozoa of mollusks, I repeat, in part, the valuable results which Pagenstecher published many years back and which have a permanent value in relation to the origin of parasitic diseases resulting from flukes. In the memoir quoted below, Pagenstecher gives the following conclusions (*Schlussbemerkungen*):

"(*a*).—The eggs of the trematoda vary in respect of size, form, and color, being either furnished or not with a lid, and accordingly distinguishable. In the mature condition they

contain a ciliated or a non-ciliated embryo of unequal growth, this embryo partly increasing in size even after its birth. In various conceivable ways the eggs themselves, or the embryos which have quitted their shells, arrive in and upon the bodies of mollusks, where they are consequently found. In this situation the egg opens, or the ciliated covering decays, and the contained motionless germ—which in itself offers no distinctive characters—having become free, grows into a nurse, or forms several nurses within itself.

"(*b*).—Whilst some of the trematodes display a highly organised nurse condition, others exhibit only a simple kind of germ-sac. Both forms, nevertheless, appear to occur in one and the same species, probably depending upon external causes.

"(*c*).—The organised nurses (or *rediæ,* as they are termed) have a mouth and a strongly marked muscular œsophagus, which is continued into a short or prolonged, single, blind intestine, or the latter may be double. The expulsion of animals developed within them I have only seen to take place through an opening at the hinder extremity. Old rediæ lose their structure. I did not observe any vascular system. Tailed trematode larvæ (*Cercariæ*), as well as rediæ themselves, are developed within the rediæ, this variation of nurse-contents probably depending on the season.

"(*d*).—No independent new germ-sacs are developed within the simple unorganised germ-sacs (sporocysts), and only such trematode larvæ as are capable of arriving at sexual maturity are furnished with special appendages.

"(*e*).—When the immature contents of both nurse forms (*i.e.* of sporocysts and rediæ) are accidentally set free, and are situated within the organs of nutrition of the living host, then they appear prepared to develop themselves anew into nurse forms; and, moreover, cercariæ whose development has not yet attained a definite stage—and even their tails also—appear to enjoy a similar capacity. Some nurses are likewise capable of multiplication by division and budding.

"(*f*).—Some germ-sacs have the property of developing within themselves cercaria-like larvæ—which are different from the true cercariæ—from whose body the development of a *distoma* may take place, while their single or double tail-like appendages in all cases develop anew into germ-sacs. To this class belong *Bucephalus* and *Distoma duplicatum.*

"(*g*).—All the cercaria at present known are destitute of

eyes, but other forms of trematode larvæ are furnished with visual organs. Accordingly, I never found eyes in young distomata whilst they were in their last dwelling-place, but eyes are certainly present in the young forms of *Polystoma* and *Amphistoma*. The supposition that a spontaneous wandering is associated with eyes is not yet confirmed in my experience.

"(*h*).—As a means of distinguishing the different forms of Cercariæ, amongst other indications, their places of dwelling may be useful, because each mollusk only harbors a limited number of species. Notwithstanding, Professor Filippi is in error if he believes that every species of mollusk carries only a single armed form of cercaria. A migration of the cercaria is indispensable to its perfection.

"(*i*).—Many larval trematodes form cysts round themselves, probably by means of a special organ of secretion, and also by the epidermis. Their future destiny necessitates this. The sporocysts apparently fulfil towards the larvæ, which are developed within them, a similar purpose, namely, a protection against the stomachal digestion of the new host. In the pupa condition the development of the larva, which has now thrown off the tail, makes greater or less progress, according as to whether it is surrounded by nourishment or not. In particular, while in this stage, the different kinds of hooks for migratory purposes make their appearance, always, without doubt, after the shedding of the skin. Other trematodes pass through this tail-less sexually-immature stage without any cyst. I have not yet seen any larval trematode forms which had been produced in sporocysts or rediæ without appendages; they appear to occur, nevertheless.

"(*k*).—As the larvæ exist only in a few hosts—and most of them dwell only in one species of animal—so, also, the continued progress towards sexual maturity only succeeds in the case of certain well-defined larval organisms, but the digestion of the cysts and liberation of the larvæ may be accomplished in various animals.

"(*l*).—The armed Cercariæ appear to be larvæ of the spine-covered distomes of amphibia; for, as examples, the *Cercaria ornata* becomes transformed into *Distoma clavigerum*, and *C. armata* into *Distoma endolobum;* the *Dist. duplicatum* and *Cerc. diplocotylea* are, apparently, the juvenile forms of *Dist. cygnoides* and *Amphistoma subclavatum*. The *Dist. echiniferum* of Paludina could neither be advanced in development in the

frog or duck, nor could all the other larvæ which I subjected to experiment be developed either in the green or brown frogs.

" (*m*).—When young trematodes arrive at the right place for their maturation, then the male generative structures develop before the female organs, and in the subsequent excess of egg production the form and structure of the animal becomes obliterated.

" (*n*).—The yelk-molecules surrounding the germinal vesicle are not directly transformed into an embryo."

As regards the acanthocephalous parasites of reptiles, I may observe that *Echinorhynchus anthuris* is very common in the lesser water newt (*Lissotriton punctatus*). In the accompanying illustration (Fig. 76) I have represented the free ovarian

FIG. 76.—*Echinorhynchus anthuris*. 1, Attached to the intestine; 2, specimen enlarged; 3, ovarian vesicle, including germs; 4, germs in various stages; 5, vesicle with germs more advanced; 6, 7, eggs in their capsules; 8, free egg. Original.

egg-bearing bodies, the development of the ovum, and the adult worms. For anatomical details, however, I must refer to my earlier treatise (' Entozoa,' p. 100 *et seq.*).

Amongst the species of entozoa that were found by me at the Zoological Society's Menagerie I may mention *Distoma coronarium* and *Ascaris lineata*, from the intestines of *Alligator mississippiensis; Dist. Boscii*, from an American snake (*Coluber*); an immature nematode, from the heart of *Coluber Blumenbachii;* and *Echinorhynchus inflexus*, attached to the intestines of a snapping turtle (*Chelydra serpentina*). I may add that the

lungs of the alligator also contained examples of Diesing's *Pentastoma oxycephalum.* An Egyptian hooded snake (*Naia haje*), which died at the Zoological Gardens in 1859, furnished a new species of pentastome (*P. multicinctum*). Dr George Harley described and anatomised this worm with remarkable care. To Harley's memoir Prof. Leuckart did ample justice in his work on the 'Pentastoma.' Several new species of reptilian entozoa have recently been described by Dr von Linstow; and Dr Solger has found a new trichosome (*T. recurvum*) beneath the skin of a young crocodile (probably *Croc. acutus*). For further particulars I refer to the revised descriptions and additions by Diesing, Molin, Schneider, and other systematists.

BIBLIOGRAPHY (No. 58).—*Baird, W.*, "Description of a new Entozoon from the Diamond Snake," in 'Proceed. Zool. Soc.' for 1865, p. 58, and in 'Ann. Nat. Hist.' for July, 1865, p. 52.—*Blanchard*, "On Polystoma," 'Ann. des Sci. Nat.,' 3e ser., viii, p. 331.—*Canton, E.*, "An account of some Parasites attached to the Conjunctivæ of the Turtle's Eyes," 'Quart. Journ. Micr. Sci.,' and 'Dublin Med. Press,' 1861 (with remarks by myself).—*Cobbold*, 'Notes,' &c. (l. c., Bibl. No. 57), and in 'Linn. Trans.,' 1857.—*Crisp, E.*, "Note on Cysticerci and Trichocephali from an Alligator," 'Path. Soc. Trans.,' 1854.—*Diesing*, 'Revision der Cercarieen,' 1858; 'Revis. der Myzelminthen,' 1858; 'Nachträge (u. s. w.),' 1859; 'Revis. der Nematoden,' 1860; 'Revis. d. Turbellarien,' 1861; 'Revis. d. Cephalocotyleen,' 1863.—*Idem*, 'Monographie d. Gatt. Amphistoma und Diplodiscus,' and 'Nachträge zur Monog. der Amph.,' 1839.—*Dujardin*, 'Hist. d. Helm.' (l. c., pp. 320, 526, &c.).—*Eberth*, "On *Myoryktes Weismanni* from the Muscles of the Frog," trans. by Busk, from 'Siebold und Kölliker's Zeitschrift,' in 'Lond. Micr. Journ.,' Jan., 1864.—*Gastaldi*, 'Cenni sopra alcuni nuovi Elmint.,' Torino, 1854 (new flukes from frogs and salamanders).—*Glüge*, "On Entozoa in the Vessels of Frogs," from 'Comptes Rendus,' in 'Micr. Journ. and Struct. Rec.,' p. 207, 1842; see Grübe and Valentin.—*Grübe*, "On the Entozoa of the Frog, and on the Pathology of that Batrachian," from 'Comptes Rendus,' in 'Micr. Journ. and Struct. Rec.,' p. 246, for 1842; see also Mandl.—*Harley, G.*, "On the Anatomy of a new Species of Pentastoma found in the Lung and Air-sac of an Egyptian Cobra," 'Proc. Zool. Soc.,' June, part xxv, p. 115, 1857.—*Leuckart*, 'Bau und Entwickelungsgeschichte der Pentastomen,' Leipsig, 1860.—*Linstow*, 'Enthelminth.' (l. c.,

Bibl. No. 57).—*Macalister, A.*, "On the presence of certain Secreting Organs in Nematoidea," 'Ann. and Mag. of Nat. Hist.' for 1865.—*Idem*, "On the Anatomy of *Ascaris dactyluris*," 'Proc. Nat. Hist. Soc. of Dublin,' vol. iv, 1865.—*Mandl*, "Development of Entozoa (*Ascaris nigrovenosa* of the frog)," from 'Rep. of French Acad. of Sci.,' in 'Month. Journ. of Med. Sci.,' vol. ii, p. 1081, 1842.—*Molin*, 'Monog. del gen. Myzelminth; Mon. del gen. Physaloptera; Mon. del gen. Histiocephalus; Mon. del gen. Spiroptera;' Wien, 1859–60.—*Pagenstecher*, 'Trematodenlarven und Trematoden,' Heidelberg, 1857.—*Sibbald, J.*, "On the *Nematoideum natricis*," 'Path. Soc. Trans.,' vol. viii, 1857.—*Solger*, "Ueber eine neue species von Trichosoma," 'Arch. f. Naturg.,' 1877.—*Valentin*, "On Parasites in the Bladder of the Frog" (from 'Repertorium'), in 'Micr. Journ. and Struct. Record,' 1842, p. 183.—*Vogt, C.*, "On Filaria in the Vessels of the Frog," from 'Müller's Archiv,' in 'Micr. Journ. and Struct. Rec.,' p. 241, 1842.—*Wedl, F.*, "Beiträge zur Lehre von den Hæmatozoen," 'Sitzungsb. Akad.,' Wien, 1850 (from the blood of frogs, &c.).—*Zeller, E.*, "Weiterer Beitrag zur Kentniss der Polystomen," 'Sieb. und Köll. Zeitschrift,' 1875.

Part III (Pisces).

Swarms of entozoa infest fishes, and it is hard to say whether they are less numerous in the inhabitants of fresh water than in those of salt water. More attention has been paid to the helminths of the fishes than to the internal parasites of birds and reptiles, consequently, the number of known species must be estimated by many hundreds. In like manner a great deal has been written respecting the ectozoa of fishes. These parasites, often called fish-lice, belong chiefly to the haustellated crustaceans, and are better known by the title of *Epizoa*. No account of them can be afforded in this treatise, but some trifling notice of the literature of the subject will be given below.

About a hundred distinct species of fluke have been described as infesting fishes. Not many of these worms possess more than a zoological interest; nevertheless, from that point of view certain types are very curious. Most of the species dwell in the stomach and intestines, but, as more or less remarkable exceptions, I may mention *Distoma seriale* infesting the kidney

of *Salmo umbla*, *D. longum* (Leidy) from the pharynx of *Esox estor*, *D. polymorphum* from the urinary bladder of the common pike (*Esox lucius*), *D. obesum* from the gall bladder of *Salminius* and other Brazilian fishes (*Xiphostoma*, *Leporinus*), *D. tornatum* attached to the gills of *Coryphæna hippuris*, *D. rosaceum* attached to the palate of *Lota communis*, and *D. contortum* attached to the gills of *Orthagoriscus mola*. Most of the forms found encysted are sexually-immature worms. To these belong *D. annuligerum*, found by Nordmann in cysts in the vitreous humour of the eye of the perch (*Perca fluviatilis*), and *D. embryo* from the liver and peritoneum of *Acerina vulgaris*. One of the largest and most remarkable of the flukes inhabiting marine fishes is the *Distoma clavatum*, found by Tilesius in the stomach of *Pelamys*, by Pohl in *Thynnus*, and by Bosc in *Coryphæna*. In the last-named fish it has been found adhering to the gills, in the liver, and in the intestines. In August, 1865, I obtained this parasite from a sword-fish (*Xiphias gladius*), and in the same piscine host I also found examples of four other species of helminths (*Tetrarhynchus attenuatus*, scolex of another tetra-rhynch, *Bothriocephalus plicatus*, *Ascaris incurva*). Believing *Distoma clavatum* to represent several forms hitherto regarded as distinct, I append a few particulars respecting it. Five examples of this worm were obtained by me from the stomach of a sword-fish. Generally they varied in length from four lines to two inches. They differed somewhat in shape, but all had the so-called head and neck directed backwards. Below the ventral sucker the two largest specimens were distended with eggs and black pigment. All of them likewise exhibited more or less well-marked transverse rugæ, the last ring surrounding an orifice which represented the outlet of a large contractile vesicle. The eggs averaged $\frac{1}{800}''$ in length.

When revising the entozoa of the Museum of the Royal College of Surgeons I encountered many parasites without labels attached. Amongst these were several flukes, which, though differing from each other in size and shape, appeared to be identical. One of these specimens turned out to be the particular *Distoma clavatum* described and figured by Professor Owen in the 'Zoological Society's Transactions.' Several of the others I made out to be part of a series contributed by Mr George Bennett, who also gave specimens to the British Museum, but the College Museum stores contained yet a third group of specimens of uncertain history. The large fluke

described by Prof. Owen was formerly in the collection of the Rev. Lansdown Guilding. In Dr Baird's catalogue the specimens presented by Mr Bennett are stated to have come from the stomach of a bonito, and probably Mr Guilding's specimens may be referred to the same "host." Be that as it may, the specimens differ from each other in a very striking manner. In the year 1730 M. Garsin first described this worm under the generic title of *Hirudinella*. He says:—"Cet insecte tiré de l'estomac de la Bonite ne vécut qu'environ deux heures. Exposé à l'air il étoit languissant, et reprenoit de la vivacité dans de l'eau de mer. Il diminua sensiblement de volume pendant qu'il vivoit encore." M. Garsin's description is accompanied by three figures. His specimens do not appear to have exceeded $1\frac{1}{2}''$ in length. In 1774 Pallas described a trematode (*Fasciola ventricosa*). It measured two inches in length. All that he says regarding its source is as follows:—"Ex Amboyna missum fuit singulare hoc molluscum, quod ad aliud quam Fasciolarum genus referre non potui, in quo quasi gigas erit." He remarks upon its pale white color, and notices particularly the soft elastic body proper, which when wounded gave out a dark matter resembling soot. This material, when examined with the microscope, appeared fresh; it was not the result of decomposition. Pallas also gives many other details, accompanied by a figure. In 1790 Menzies likewise described and figured a fluke about two inches long. He calls it *Fasciola clavata*:—"It is of whitish color, somewhat pellucid, discharging at its mouth a black-colored fluid, which can easily be perceived through its body. I have often found it," he adds, "in the maws of the bonito, between the tropics in the Pacific Ocean." Notwithstanding the similarity of description, Menzies does not appear to have recognised the identity of his worm with that described by Pallas. Prof. Owen, however, subsequently established this identity, and referred to this species as the *Fasciola clavata* seu *ventricosa*. On the other hand, the British Museum Catalogue represents Pallas's worm as specifically distinct from that of Menzies, but as identical with the specimen described by Prof. Owen from Mr Guilding's collection.

In 1802 Bosc described and figured a trematode under the title of *Fasciola fusca*. This he obtained from the intestines of a dorado. In form it differs considerably from the foregoing species. Bosc's description runs as follows:—"Brune, la partie postérieure très-renflée, presque ovale, la partie

antérieure mince, cylindrique, inégale, avec deux petits tentacules en dessous. Le suçoir de l'anus très grand." Bosc recognised the identity of this worm with the *Distoma coryphenæ* of Rudolphi, and systematists generally have adopted his synonymy. In the British Museum Catalogue the *Fasciola fusca* and *F. ventricosa* of Pallas are regarded as one and the same species. The existence of two small tentacles is certainly peculiar.

In 1827 Nardo obtained two very large flukes from the stomach of a fish captured in the Gulf of Venice during the month of September. He calls the fish *Prostostegus prototypus*, which appears to be the same as the *Luvarus imperialis* of Rafinesque. One of the parasites, being five inches in length, he named *Distoma gigas*. His description is as follows :—"Distoma teres, rubrum, retractile; poro ventrali minimo cujus apertura magna, rotunda, ciliata; poro antico terminali, parvo; collo brevi, retrorsum divergente, extensili, apice angusto, basi lato; cauda longa, postice incrassata et in apice obtusa oscula donata." The alleged ciliated character of the ventral sucker, was perhaps due to a wrinkled state of the lip. Apart from this character, I see no reason for supposing this parasite to be distinct from the *Distoma clavatum* procured by Mr Guilding, or the *Fasciola ventricosa* described by Pallas. The intestines of the fish harbored another parasite (*D. Raynerianum*). Unfortunately, Nardo gives no figure of *Distoma gigas*. It is the longest fluke known to science.

In the year 1835 Professor Owen communicated the memoirs already alluded to. In his paper he discussed questions relating to the structure of *Distoma clavatum*, and threw much light upon its anatomy, but I believe that the large "lateral cavities" described by Owen are neither more or less than the somewhat unusually distended alimentary cæca.

In 1845 Dujardin placed the worm with the true distomes, yet, at the same time, expressed grave doubts as to whether it were, in any sense, a fluke. "Ce ver," he remarks, "n'est certainement pas un distome ni même un trématode. Si sa forme extérieure et ses deux oscules lui donnent quelque ressemblance avec les distomes, sa structure musculeuse la rapproche davantage des Gordius, et son tégument ressemble à celui des siponcles." M. Dujardin examined the specimens preserved in the Paris Museum, and with regard to one particular example, described as "Fasciola, trouvé dans la mer de Nice,"

he says, it presents "une certaine analogie avec le prétendu *Distoma clavatum.*" Dujardin himself was somewhat puzzled by the resemblance in question. He does not appear to have examined fresh specimens, yet he mentions the species as tolerably common in the bonito, and occasionally present in the tunny. At all events, it appears that the rightly so-called *Distoma clavatum* is not unfrequently taken from the ocean in the free state. In concluding my notice of this remarkable worm I can only add that after examining numerous specimens both in the fresh and preserved states, I have formed the opinion that the following specific names all refer to one and the same parasite:—*Distoma clavatum,* Rudolphi; *D. coryphœnæ,* Rud.; *D. gigas,* Nardo; *Fasciola clavata,* Menzies; *F. coryphœnæ,* Bosc; *F. coryph. hippuridis* and *F. Scombri pelamidis,* Tilesius; *F. fusca,* Bosc; *Hirudinella marina,* Garsin; *H. clavata,* Baird. In this list of synonyms we may probably also include Rudolphi's *Distoma tornatum.*

FIG. 77.—*Echinostoma hispidum.* Magnified. Original.

In addition to these distomes there are numerous piscine flukes which may fairly be relegated to other genera. Thus, provisionally, I elevated Dujardin's sub-genus *Echinostoma* into a separate genus; and on what I considered sufficient grounds I established several other new genera from amongst the more curious flukes that had been described as infesting fishes (*Wedlia, Köllikeria*). In the genus *Echinostoma* the oral sucker is either surrounded by a circle of little spines, or it occupies the centre of a disk, which is cleft at the ventral or anterior aspect. In the latter case the disk is either bordered both laterally and above by spines, or there are two large lobed appendages, whose margins are

furnished with spines. In other respects this genus nearly corresponds with the distomes, the simple digestive tubes bifurcating immediately below the œsophageal bulb. The specimen of *Ech. hispidum* here drawn (Fig. 77) was taken by me from the spiral intestine of a sturgeon (1855), in which fish it occurs very abundantly. The figure represents a back view of the head and a lateral view of the body, the neck having been slightly twisted. The ventral sucker is concealed, but the transparency of the skin permits a view of the internal organs.

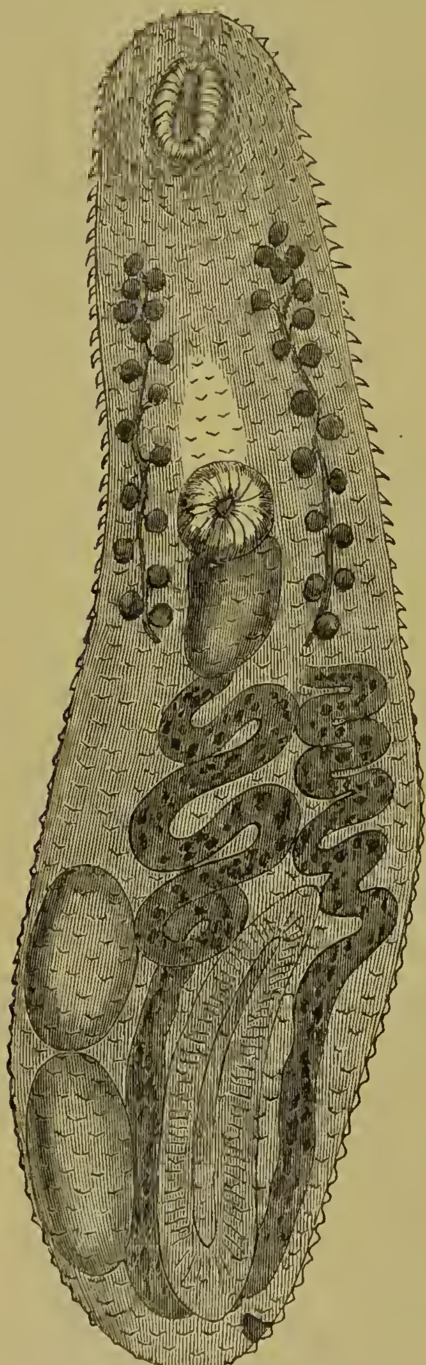

Fig. 78.—*Gasterostoma gracilescens.* Magnified. Original.

Another remarkable genus, established by Von Siebold, is *Gasterostoma.* In this genus the ventral sucker has taken the position usually assigned to the oral opening; the latter being near the centre of the body. The digestive cæca also disappear, leaving only a short stomachal cavity, which reminds one of the same viscus in imperfectly organised sporocysts or rediæ. When *G. gracilescens* first came under my observation I followed Rudolphi in describing it as a distome (*D. gracilescens*). The anatomy of the genus has been illustrated by Von Siebold; from whose observations also it may be inferred that the larvæ are various forms of *Bucephali.* Prof. Molin describes the water-vascular or respiratory apparatus as consisting (in *G. fimbriatum*) of a broad central tube, occupying the entire length of the body and opening externally at the tail.

Amongst the more remarkable fluke-types may be mentioned Van Beneden's Nematobothrium (*N. filarina*), occupying the branchial cavity of *Sciæna aquila,* also *Holostoma clavus,* found by Molin in the intestines of *Gadus merlucius,* also *Köllikeria filicollis,* occupying

open follicles in the branchial cavity of *Brama Raii.* The sexes in the last-named genus are distinct; male and female worms together occupying each cyst. The genus *Monostoma* is also largely represented amongst fishes. Prof. Wedl found a species (*M. Wedlii*) occupying follicles in the intestinal mucous membrane, and also adhering to the fin rays of *Rhombus lævis.* I also found a species (*M. dubium*) in a cyst attached to the ovary of *Gasterosteus spinachii.* Several species of amphistomatoid worms were found by Natterer in Brazilian fishes (*Cataphractus,* &c.), some of these representing distinct genera (*Aspidocotylus, Notocotylus*), to which I found Sonsino's remarkable fluke (*Gastrodiscus Sonsinonis,* mihi) from the horse to be very closely allied. In this connection must also be mentioned Grübe and Wagener's curious *Amphiptyches urna,* found attached to the branchiæ, and also in the intestines of *Chimæra monstrosa.*

In addition to the above families and genera of digenetic flukes infesting fishes we have the monogenetic tristomes and polystomes. As remarked in my introductory treatise, the Tristomidæ display a leech-like aspect, in consequence of which they have been placed either along with the *Malacobdellidæ,* or in some other allied family of the suctorial annelids. The tristomes are not strictly entozoa, yet their internal organisation conforms more to the *Trematoda* than to the *Hirudinidæ.* Thus, they support two small suckers anteriorly and one large sucker posteriorly, the body being externally smooth and devoid of annulations. The tristomes have therefore no anus. In some species the large caudal sucker is sessile, in others it is stalked or pedunculated, being in either case bordered by a membranous fold (Dujardin). All the species are hermaphroditic. They attach themselves to the gills of fishes or to the general surface, selecting especially the neighbourhood of the fins. Some species are parasitic on crustacean parasites that are themselves attached to marine fishes. In the genus *Udonella* the mode of development is known to be simple and direct. According to Van Beneden, the embryos are large and acquire the form and characters of their parents whilst they are still within the egg-shell. They are ready to assume an independent existence the moment they quit the shell. The eggs are oval, the chorion being prolonged into a single filamentary process or "holdfast." Van Beneden compares a group of them to a "bouquet of vorticells." On quitting the shell the embryonic *Udonella* at once

attaches itself to the *Caligus*, and there acquires the adult condition. The *Polystomidæ* comprise a variety of remarkable genera. I accept this family as the equivalent of Dujardin's first group of trematodes which he termed "*Onchobothriens*," rejecting only his genus *Diporpa*, which is a juvenile condition of *Diplozoon*. In this family Van Beneden includes the genera *Calceostoma* and *Gyrodactylus*. In all the polystomes we have a more or less ramified intestine, but the reproductive organs conform to the general trematode type. All are hermaphroditic, the eggs being supplied with filamentary appendages, in some only at one pole of the shell, in others at both ends. The water-vascular system is conspicuously developed. All the species are supplied with prehensile hooks.

In the Diporpa condition of *Diplozoon* there are two supernumerary hooks, associated with a dorsal sucker at the centre of the body, and it is by means of these organs that a conjugation between two such juvenile forms is effected. These two individuals become organically united for life, after the fashion of the Siamese twins. After conjugation the sexual organs appear. In *Onchotyle appendiculata* the lower end of the body merges into a curious appendage, which is placed almost at a right angle with the body itself, and in this way, as Van Beneden justly remarks, the entire animal resembles a little hammer, the resemblance being very much heightened by the circumstance that one end of the appendage is cleft so as to correspond, as it were, with the notch which we employ in the action of nail-drawing. The *Onchotyle appendiculata* was first discovered by Kuhn attached to the gills of a dog-fish (*Scillium catulus*), but it has since been found ectoparasitically lodged upon other marine fishes. With the *Gyrodactylidæ* I include Van Beneden's genus *Calceostoma*. The gyrodactyles have been classed with the Polystomidæ. Amongst the characters standing out most prominently are those having reference to peculiar hooks which project from the great sucking disk. In *Calceostoma* this mechanism is reduced to a single horny structure placed at the margin of the caudal sucker in the central line. In some Gyrodactyli the hooks are very numerous. In *Gyrodactylus elegans* the caudal sucker supports a pair of large laterally-curved hooks, which are placed back to back in the centre of the disk, being connected at their upper ends by a supplementary semi-lunar bar. A series of tentacles serve to increase the prehensile action of the sucker. In many species the males

are supplied with accessory horny developments. The genus *Gyrodactylus* has been studied by Nordmann, Von Siebold, G. Wagener, Van Beneden, and especially by Wedl, who records the following results :—(*a.*) "*Gyrodactylus* is found on the gills of fresh-water fishes under numerous specific forms, *G. elegans* being also found by Creplin and Siebold on the fins. Moreover, as I have found nearly every species of fish supporting a particular gyrodactyle representative, it would seem that each finny creature supplies its own *Gyrodactylus*. Sometimes two of them are parasitic upon the same gill, being frequently associated with *Trichodinæ*, as well as with the still unintelligible *Psorospermiæ*. (*b.*) The clasping apparatus at the posterior end of the body must—in an animal so soft and constantly exposed to the passage of regular currents—be comparatively strongly developed and accommodated to the peculiar dwelling-places, and probably the varying character of the latter supplies a reason why there should be so great a difference in the mechanism of the hooks belonging to the disk. (*c.*) The hooked apparatus affords a very valuable and mathematically precise means of diagnosis in the determination of species. This differentiation may be accomplished by observing whether there are two or four large hooks; whether there be one or two connecting portions, and by noticing their several forms and relations to one another; and whether, again, there are hooklets or not, remarking in the first instance their position, form, distribution, and so forth. (*d.*) The integument is sometimes wrinkled transversely, at other times appearing to be smooth. (*e.*) The muscular apparatus is, in certain cases, very strongly developed. In the majority of instances special muscles are inserted into the

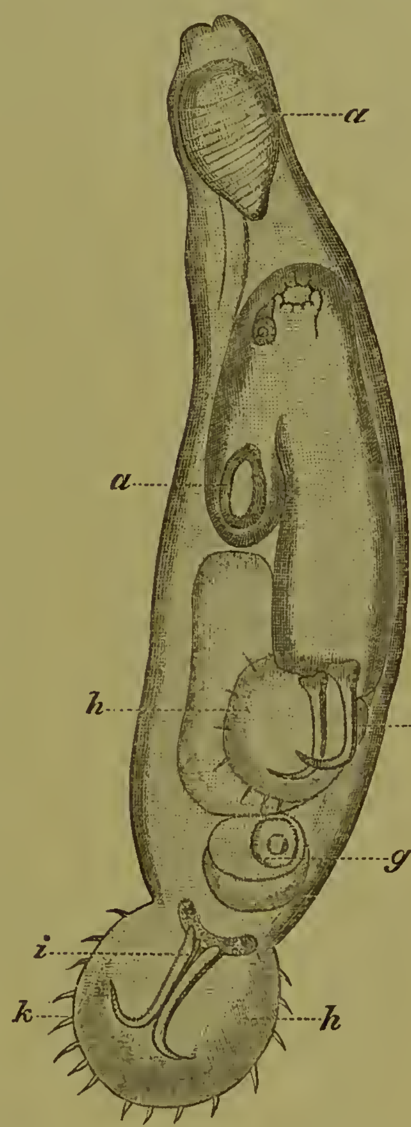

FIG. 79.—*Gyrodactylus elegans*, containing an embryo. *a*, *a*, Œsophagus; *g*, testis; *h*, *h*, sucker; *i*, *i*, large hooks; *k*, spines. Magnified. After Van Beneden.

handles of the hooks, and they are also very frequently directed into the transverse muscles of the skin. In *Gyrodactylus crassiusculus* we find a *protrusor penis* and *retractor pulparum medius*. (*f.*) Except in the case of *G. elegans*, four so-called eye-spots are observed at the anterior extremity of all Gyrodactyli. As Siebold says, they answer the purpose of light-refracting organs. The palpi, which in *G. crassiusculus* are seen to contain muscular bundles, appear to be retractile touch-organs, extending more or less prominently forward. (*g.*) Observations in regard to the alimentary canal are at present incomplete, for only in the case of *G. cochlea* did I find a single gullet demonstrable. (*h.*) *Gyrodactylus* becomes sexually developed, and cannot be regarded merely as a kind of 'nurse.'"

So much for Wedl, whose views I have elsewhere recorded at great length. The genetic relations subsisting amongst the Gyrodactyles have given rise to much controversy. Observing the singular mode of reproduction in *G. elegans*, Von Siebold arrived at the conclusion that Gyrodactyles in general were only nurse-forms of some higher organism, and he pointed out, with undeniable accuracy, all the birth-stages of the young one as it apparently pullulated within the parent and subsequently emerged an almost perfect Gyrodactyle. Von Siebold also remarked that the so-called "daughter," at the time of birth, nearly equalled the "parent" in respect of size, whilst, moreover, it contained within its interior another very young Gyrodactyle, or, in other words, a "grand-daughter." Van Beneden interpreted these facts very differently. I have myself noticed the second generation, or daughter, to contain in its interior evidences of a third generation. This I observed in specimens obtained from the tails of Gasterostei caught in the Serpentine, Regent's Park. Indications of the third progeny were seen whilst the daughter still resided within the body of the nurse-parent, and the so-called grand-daughter became much larger immediately after birth. In one instance the "daughter" commenced showing herself by a slight bulging at the centre of the parent's body, whilst the integument of the latter yielded on all sides of the bud-like projection, and in such a manner as to convey the idea of a vaginal opening. There was an evident struggle on the part of the young one to free itself from the so-called parent envelope, but the tissues showed no signs of injury. On partial protrusion it was seen

that the budding portion corresponded with the centre of the daughter's body, and this, in a little while, assumed the aspect of a semicircular band. Subsequently the upper end became detached, the freed extremity being now recognised as the head. An interval elapsed before the broad posterior end of the animal could be disengaged, but immediately after this was effected the sides of the parent envelope closed in upon the opening, and all that remained was a small cavity or sac, indicating the position recently occupied by the daughter. Altogether the process occupied about five minutes. I carefully compared the so-called "parent" with the "daughter," but in regard to size I can scarcely say which was the larger of the two. As before hinted, Van Beneden demurs altogether to Von Siebold's views. He does not admit the parent to be a kind of "nurse," he does not consider the primary young one to be a "daughter," and, consequently, he does not regard the embryo seen within the latter as a "grand-daughter." Van Beneden says:—"According to our researches there is here a false interpretation; the little daughter is lodged within the side of its pretended mother, and not in its interior; instead of being its mother, it is its sister; there is a difference of shape because there is a difference of age; the Gyrodactyles are viviparous, and as among the Trematodes the eggs are formed one by one, one embryo is scarcely formed when another commences its evolution, and the egg-deposition is effected even whilst the embryo is being produced. The Gyrodactyles are therefore viviparous worms, which beget a single embryo at a time, as those of the trematode group, to which they are allied, beget a single egg at a time, and before the first embryo is expelled another is already partly developed. There, we believe, lies the correct interpretation of that phenomenon; instead of a bud it is an embryo, which has escaped from an egg. Here, therefore, we have no phemonenon of alternate generation or of digenesis, as Von Siebold supposes, but a simple viviparous reproduction."

Passing on to notice the cestodes of fishes, I may remark that they often display characters very distinctive from those inhabiting birds and mammals, being commonly furnished with special tentacular hook-appendages employed as supplementary organs of boring and anchorage. In the cartilaginous sharks and rays these cestodes are remarkably abundant, and in certain osseous species they are scarcely less frequent. The only noteworthy kinds of fish which are commonly free from the

invasion of tapeworms are the sturgeons, blennies, gobios, mullets, sparoids, and Sciænæ. Some few of them are infested by *Ligulæ, Caryophyllæi,* &c. Cuttle fishes harbor a great variety of tapeworm-larvæ, forming one of the chief sources whence sharks and rays obtain the same parasites destined to arrive at sexual maturity within their own bodies.

Among the most interesting cestodes of fishes we may reckon the pit-headed tapeworms and their allies (Bothriocephalidæ). One of the most common species is *Both. proboscideus* which

FIG. 80.—Section of the strobile of *Bothriocephalus proboscideus.* Magnified. After Busk.

is found, often in considerable numbers, lodged within the pyloric appendages of the salmon (*Salmo salar* and *S. hucho*). It acquires a length of two feet. When in large numbers it cannot fail to prove injurious to the bearer. In this connection also must be mentioned *B. nodosus.* In the adult state this worm infests a great variety of water-birds (herons,

gulls, and divers), but in the young or sexually-immature tænioid condition it is a frequent inhabitant of sticklebacks (*Gastereosteus aculeatus* and *G. pungitus*), being also found in the salmon and in the bull-head, or father-lasher (*Cottus scorpio*). The immature tapeworm was formerly considered a separate species (*B. solidus*). Some years back Creplin discovered the connection subsisting between the two forms, and re-described the species in its two conditions under the name of *Schistocephalus dimorphus*, but it was reserved for Von Siebold to explain the full nature of this relationship. In his essay on "Tape and Cystic Worms" he shows that it is not until the worm reaches the intestine of the ultimate host that its segments acquire sexual completeness. As Von Siebold observes, "the extent of development in each individual will be found to be in proportion to the time the parasite has passed in the bird's alimentary canal after its passive immigration." A similar instance, it is added, "occurs in the case of the *Ligula simplicissima*, infesting the abdominal cavity of various species of carp, whose sexual organs are, and remain, undeveloped as long as the worm resides within the fish; whilst, when the latter is eaten by ducks, divers, waders, and other water-fowl, the entozoon being thus conveyed into their intestine, it attains perfect sexual development. In the older helminthological works the sexually-mature *Ligula simplicissima* is described under various specific names (*L. sparsa, L. uniserialis, L. alternans, L. interrupta*)." These results have been confirmed by later observers, but it is now usual to recognise the sexually-mature worm as the *Ligula monogramma* of Creplin. In 1876 Dr Duchamp published his beautiful memoir on this subject, treating the entire question exhaustively and adding important experimental details. M. Duchamp gives a list of about twenty species of fish that are infested by the immature worm, and amongst these the *Cyprinidæ* play by far the most conspicuous part. M. Duchamp has recorded a fatal piscine epizoöty amongst tenches (*Tinca vulgaris*), occurring in the ponds of La Bresse. This is produced by *Ligula simplicissima*, which escapes by an aperture formed near the vent of the infested fish. M. Duchamp also gives important anatomical and embryological details, but the especially interesting part of his memoir refers to his feeding experiments, seven in number. He succeeded in rearing *L. monogramma* in the domestic duck, by feeding this bird with examples of *L. simpli-*

cissima obtained from the abdomen of the tench (*Tinca vulgaris*). The interest of these experiments does not cease here, since they afford a probable clue to the source of human *Bothriocephali*, which in nearly all essential points of structure correspond with the Ligules. As remarked in the first part of this work, Leuckart long ago pointed to the Salmonidæ as probably furnishing the intermediate host of this worm; and he disproved the views of Knoch, of Petersburg, who thought he had reared *Bothriocephalus latus* in the dog in a direct manner. I have already called attention to the opinion of Dr Fock, of Utrecht, who thinks the human bearer may become infested by the consumption of the little fresh-water bleak (*Leuciscus alburnus*). From the observations of Dr Bertolus, it is extremely probable that our *Bothriocephalus latus* is the sexually-mature condition of *Ligula nodosa* infesting the abdominal cavity and pyloric appendages of the common trout (*Salmo trutta*).

Another cestode of general interest is the *Tricuspidaria* (*Triænophorus*) *nodulosus*, infesting many of our fresh-water fishes. It varies in length from one to two feet. The segmentation of the strobila is very indistinct, but the reproductive organs occur at regular intervals. All parts of the body are extremely contractile, especially the head. The tricuspid hooks support thin chitinous laminæ, which connect the two lateral horns of each hook to the central apophysis. The object of this arrangement is to afford additional security to the prong-like processes. Van Beneden appears to think it an error that the cusps of the hooks should have been figured in 'Règne Animal' as directed forwards, and he has drawn the hooks with the points downwards. In regard to the calcareous corpuscles, narrow vessels may be easily recognised passing off continuously from the capsules in closing the particles. These vascular prolongations are single, having their course directed towards the epidermis; doubtless they open at the surface, but I did not detect any aperture. I have figured the tubes in my 'Entozoa' (p. 132). Dr Guido Wagener figures similar structures as occurring in *Cercaria macrocerca*.

Various species of *Tetrarhynchus* dwell in the bodies of sharks and rays, whilst their larvæ inhabit fishes on which the plagiostomi feed. Immature tetrarhynchs occur in cuttle-fishes, but they are most abundant in such fish as the cod, haddock, turbot, whiting (Fig. 81), flounder, sole, gurnard, mackerel,

mullet, and conger-eel. A tænioid scolex constantly infests the muscles and viscera of the great sunfish. The tetrarhynchs differ from one another as regards the form of their proboscides and the relative number and disposition of the hooks. I must refer to my 'Entozoa' for a full description, with figures, of a larval tetrarhynch from the wall of the intestine of a haddock. Some Tetrarhynchi exhibit a very complex armature, as may be seen in *Tetrarhynchus longicollis* infesting the tope or penny dog-fish (*Galeus vulgaris*). In this species the hooks are uniform in size, and arranged in spirally disposed circles carrying from twenty to thirty hooks each. In the tetrarhynch from the whiting the hooks show much irregularity both as regards size and arrangement. A remarkable scolex infests the sun-fish (*Orthagoriscus mola*); it is a true tetrarhynch, but has been variously classed. According to my view all the following titles refer to this parasite :—*Gymnorhynchus reptans*, Rudolphi; *G. horridus*, John Goodsir; *Acanthorhynchus reptans*, Diesing; *Bothriorhynchus continuus*, Van Lidth de Jeude; *Bothriocephalus patulus*, Leuckart; *Acanthocephalus elongatus*, Rudolphi; *A. macrourus*, Bremser; *Floriceps saccatus*, Cuvier; *F. elongatus*, Blainville; *Scolex gigas*, Cuvier; *Tetrarhynchus reptans*, Cobbold.

FIG. 81.—Portion of the proboscis of a scolex of *Tetrarhynchus* infesting *Merlangus vulgaris*. Magnified. After Busk.

Five or six examples of the sunfish have been examined by me in the fresh state, all of them being infested by tetrarhynchs. In the fish here drawn (fig. 82) the liver and lateral muscles were extensively tunnelled by the parasite. In all instances the anterior part of the worm was found surrounded by a thick, clear, transparent cyst, which gradually diminished in thickness towards the tail. When liberated from its investing capsule the head of the worm presents a quadrilateral figure, each lateral half being furnished with a bipartite facet. The retractile boring organs are club-shaped, each supporting about 1600 hooks. Nearly all the hooks display a uniform length and thickness, but at the lower part of each proboscis there are two conspicuous circles, the hooks of which are at least twice as large as the others. The joints of the immature strobile are well formed, but exhibit no trace of sexual organs. If it be

asked "what is the object of this perpetual tunnelling," and "does the boring cause suffering to the host," I reply:—"The object of tunnelling is apparently twofold; first, that the parasite may constantly obtain fresh nourishment; and secondly, that it may acquire another residence." It furnishes an example of a parasite perpetually striving to perform an act which it cannot accomplish; for, in order to arrive at sexual maturity, it must wait until the sunfish is devoured by a shark. In regard to the question as to the boring action giving rise to pain, one cannot, of course, speak with absolute certainty. When there are many parasites occupying the liver, or other important viscera, then, doubtless, they create pain, and cause decay of the organs infested; thus they enfeeble the vital powers of the host. At such a time the sunfish would be easily overcome by its natural enemies, and be the first to succumb in the struggle for existence. These wandering tetrarhynchoid scolices never escape the body of the intermediate host until they are passively transferred into the alimentary canal of the ultimate entertainer. In the sharks and rays they acquire sexual maturity. From these animals the proglottides pass into the water in the ordinary way. The ova are subsequently swallowed by sunfishes and other intermediate hosts, within whose stomachs the six-hooked embryos are liberated, and the scolices become developed in the ordinary manner. As obtains in *Cysticercus fasciolaris* of the mouse the scolex of *Tetr. reptans* becomes tænioid. I have seen the liver of an adult sunfish so infested by these parasites that the whole organ might be fitly described as a mere bag of worms, the immature strobiles being inextricably coiled together and defying separation. One of the parasites which I removed from this particular fish is preserved in the Hunterian Collection.

In reference to the nematoids of fishes I can say but little. They are excessively abundant; sexually-immature filariæ being found in almost every marine fish that one examines. Even at our dinner and breakfast tables nothing is more common than to observe the little *Filaria piscium* spirally coiled within the tissues of herrings, haddocks, cod-fish, and whiting. All the sexually-immature nematoids are, as it were, waiting to be passively transferred to their ultimate hosts. These final bearers are usually either fishes, birds, cetacea, or seals. Amongst fresh-water fishes the *Cucullanidæ* play an

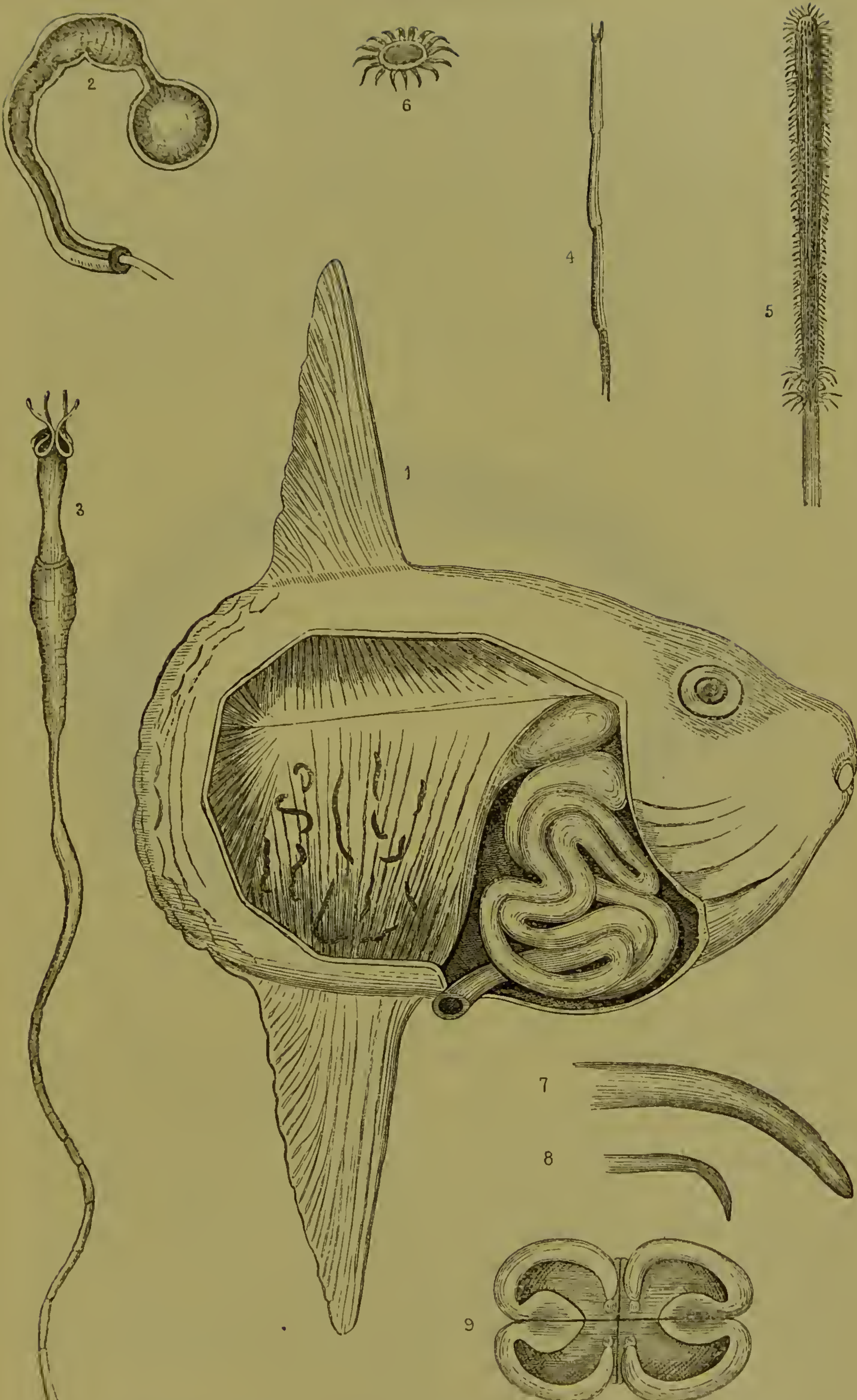

Fig. 82.—*Tetrarhynchus reptans.* 1, Reduced figure of a sunfish, showing the worms *in situ*; 2, head of a worm in its capsule; 3, tænioid scolex; 4, section of the immature strobile; 5, proboscis; 6, row of hooks; 7, 8, large and small hooks (magnified 260 diameters); 9, head of the scolex viewed from above. Original.

important rôle. These parasites closely resemble the strongyloid *Sclerostomata*, but the absence of a true bursa seems to justify their separation into a distinct family. In most of them the body is truncated in front and much narrowed or drawn out posteriorly. The head is broad and globular, and furnished with a powerful muscular pharynx. The mouth is seldom round; it is often subterminal, opening by a transverse slit. The tail of the male is recurved, and usually supplied with membranous winged appendages; sometimes there is a pre-anal sucking disk. In the female the tail is simple, and more or less sharply pointed.

FIG. 83.—*Cucullanus foveolatus*. Female. From the plaice (*Platessa vulgaris*). Magnified. After Busk.

The facts relating to the development of these parasites are especially interesting as having afforded Leuckart and Fedschenko a clue to what obtains in the guinea-worm (*Dracunculus*). The Cucullanus of the perch (*C. elegans*) is a viviparous species. The embryos are supplied with little boring teeth, or styles, which enable them to perforate the bodies of entomostracous crustaceans. Having in a direct manner gained access to the perivisceral cavity of *Cyclops*, they remain coiled within the intermediate bearer until it has been pursued, captured, and transferred to the stomach of the ultimate or piscine host. Once liberated within the stomach of the fish the young *Cucullani* soon acquire sexual maturity.

The acanthocephalous *Echinorhynchi* are very abundant in fishes. They also, like the *Cucullani*, require a change of

hosts in order to ensure the continuance of the species. No less than six species of Echinorhynchi are known to infest the trout (*Salmo fario*). As many as four species likewise infest the eel (*Anguilla*); the same number of distinct forms being also found in the turbot (*Rhombus*) and ling (*Lota*), whilst three species may be met with in the common sole (*Solea*). What we at present know respecting the mode of development of Echinorhynchi infesting fishes is principally due to the researches of Leuckart. Some years back Dr Guido Wagener

FIG. 84.—1, *Echinorhynchus angustatus* (natural size and enlarged); 2, *Echinorhynchus nodulosus* (natural size and enlarged), with (3) two eggs (magnified 1000 diameters). Both species from a trout. After Busk.

supplied admirable illustrations of the eggs and embryos of Echinorhynchi, but he was erroneously led to conclude that the larvæ were developed in a direct manner. The notion of a simple metamorphosis was entirely disproved by the experiments of Leuckart, who found the growth and development of the young to be accompanied by a true alternate generation. He showed this to obtain in *Echinorhynchus proteus*, a species abundant in the trout and in many other fresh-water fishes. The

embryo of this parasite is broad and obliquely truncated at the ventral surface anteriorly, being gradually narrowed to a blunt point posteriorly, and at the front part, on each side of the middle line, there are five or six spines biserially disposed. Similar characters are seen in *E. filicollis*. Prof. Leuckart introduced a number of eggs into a vessel of water containing several small crustaceans (*Gammarus Pulex*). These little animals readily swallowed the ova, and in a few days the embryos were found emerging from their shells, boring their way through the intestinal walls, then passing into the general cavity of the body, and even into the appendages themselves. During the next fourteen days the embryos within the Gammari exhibited an increase of size; and in course of the third week a further metamorphosis caused the embryos to assume the readily recognisable characters of a young *Echinorhynchus*. Thus, in Leuckart's own words, "the ultimate animal arises in the interior of the primordial body, by a process which presents so close an analogy with the production of an embryo, and, consequently, with the act of generation, that one feels inclined at once to identify it with such an act, and therefore, also, to regard the *Echinorhynchus* as exhibiting an alternation of generation in its mode of development rather than a metamorphosis."

The young *Echinorhynchus* afterwards grows rapidly, its several internal organs, proboscideal sac, and muscular apparatus, gradually coming into view. At last the young entozoon completely fills the interior of the embryo, the latter having scarcely undergone any change, and still remaining, of course, within its crustacean host. What may be regarded as even more extraordinary is the circumstance that the embryonic body next becomes firmly adherent to the young *Echinorhynchus*, thus ultimately forming the true integument of the adult *Echinorhynchus*. The original skin of the embryo, however, is cast off "as soon as the *Echinorhynchus* occupies the whole interior of the embryo." After this the sexual differences become clearly established. Leuckart remarks that the passage of the young Echinorhynchi into their ultimate host is probably unattended by any striking changes, whilst the metamorphosis of the embryo, as thus far detailed, occupies a period of about six weeks. In general the crustacean hosts appear to suffer little from the borings of the embryo parasites, but when the latter have assumed the Echinorhynchus - condition and happen to be

particularly numerous they not unfrequently prove fatal to the unsuspecting Gammari. After their transference to the intestine of the ultimate host a period of about one week more is required for the completion of their development.

From the large number of species of *Echinorhynchi* infesting our fresh-water fishes, they present quite a feature of piscine parasitism. Almost every perch, chub, carp, pike, barbel, bream, or roach that one opens is found to have its intestines occupied by parasites which exhibit a light yellow color. These are Echinorhynchi, the common forms being *E. proteus*, *E. angustatus* (Fig. 84, No. 1), *E. clavæceps*, *E. globulosus*, and *E. tuberosus*. In the Salmonidæ, besides several of the above, we may also find *E. clavula*, *E. fusiformis*, and *E. pachysomus*. As a group these parasites are more attractive looking than most other helminths, and they will well repay the zoological collector. The species infesting marine fishes are almost as numerous as those found in fresh-water hosts.

Bibliography (No. 59).—(Anonymous), "Note by 'An Inquirer' respecting Worms in Fish," in the 'Lancet,' March 7, 1868, p. 336.—*Baer, K. E. von*, "On the Tapeworms found in the Waters of the Pregel by Linneus," from the German, in 'Edin. New. Phil. Journ.,' 1829, p. 374, and in the 'Edin. Nat. and Geo. Sci. Journ.,' 1829–30, p. 311; also from the 'Trans. of Nat. Soc. of Dantzig,' in the 'Lancet,' 1829.—*Badcock*; see *Slack*.—*Baird*, 'British Entomostraca,' London, 1850.—*Beneden, J. P. van*, "Les vers cestoides," 'Mém. de l'Acad. Roy. de Belg.,' tom. xxv, 1850. —*Idem*, 'Mém. sur les vers intest.,' Paris, 1858.—*Idem*, "On Echinobothrium," in 'Bull. de l'Acad. de Brux.,' 1849.—*Idem*, (with Hesse), 'Rech. sur les Bdellodes ou Hirudinées et les Trématodes marins,' 1863–65.—*Idem*, 'Rech. sur les Turbellaries,' 1861.—*Idem*, "On a new Lerneonema," 'Bull.,' l. c., 1851, and in 'L'Institut,' 1851.—*Bertolus*, 'Mém. sur le développement du *Dibothrium latum* (Bothriocéphale de l'homme),' App. to Dr Duchamp's work quoted below.—*Bosc*, 'Hist. Nat. des Vers,' 1802, p. 271.—*Bradley, C. L.*, "On the occurrence of Gyrodactylus on Sticklebacks," 'Proc. Linn. Soc.,' 1861.—*Brullé*, "Note on the Reproduction of Ligula," from 'Comptes Rendus,' in 'Ann. Nat. Hist.,' 1855.—*Chatin*, 'On *Amphibdella torpedinis* from the Gills' (l. c., Bibl. No. 57).—*Chavannes*, "On Fluke-larvæ from Coregonus," in 'Bull. de la Soc. Vaud. des Sci. nat.,' tom. iii.—*Claparède, E.*, "Ueber die Gattung Tetracotyle," &c., in 'Zeitsch. f. wiss. Zool.,' 1857, s. 99 *et*

seq.—*Cobbold*, "The Sunfish (Orthagoriscus) as a Host," 'Intell. Observer,' Sept., 1862.—*Idem*, "Notes on the Calcareous Corpuscles of Tricuspidaria," 'Quart. Journ. Micr. Sci.,' 1859. —*Idem*, "Notes on Tricuspidaria and Pentastoma," *ibid.*, 1859. —*Idem*, "Note on *Gyrodactylus elegans*," *ibid.*, 1862; see also Wedl.—*Idem*, "On *Distoma clavatum* from the Sword-fish," 'Proc. Linn. Soc.,' 1867 (Zool. Sect., p. 200).—*Idem*, "Tapeworms in Trout," letter to the 'Field,' July 26, 1873; see also F. Francis (below).—*Idem*, "Remarks on the Entozoa and Ectozoa of Fish," the 'Veterinarian,' Oct., 1867, p. 671.—*Idem*, "On *Agamonema crenilabri*," in 'Science Gossip,' 1876; see W. W. Wilson.—*Idem*, in 'Linn. Trans.,' 1858.—*Idem*, 'Note on Parasites from the Wolf-fish (Annarhicas) and Lump-sucker (Cyclopterus), collected by Mr Devis' (l. c., Bibl. No. 57).—*Idem*, "Descr. of the Scolex of a Tetrarhynchus," in a paper on 'Parasite Larvæ,' 'Intell. Observer,' 1863.—*Idem*, "Synopsis of the Distomidæ," 'Proc. Linn. Soc.' (Zool. Div.), 1860.—*Idem*, "Remarks on *Bothriocephalus latus*, in relation to Dr Fock's supposition that the Bleak (*Leuciscus alburnus*) is concerned in its Production," the 'Veterinarian,' July, 1878.—*Cornalia, E.*, 'Sopra una nuova specie di Crostacei Siphonostomi (*Gyropeltis doradis*),' Milano, 1859.—*Coughtrey, M.*, "On the absence of Tapeworm in the Salmon-trout of New Zealand," letter to the 'Otago Daily Times,' dated from the Otago University, Dec. 6, 1875.—*Diesing*, 'Vierzehn Arten von Bdellideen,' Wien, 1858; see also 'Revisions,' quoted in Bibl. No. 58. —*Donnadieu, A.*, "Étude sur les Ligules," in 'Archives Zool. Expériment.,' 1876.—*Duchamp, G.*, 'Recherches anat. et physiol. sur les Ligules,' Paris, 1876; see also Bertolus.—*Fock*, 'The Bleak as a source of the Broad Tapeworm.' See Cobbold.—*Francis, F.*, "Tapeworm in Fish" (with report by myself), in the 'Field,' June 28, 1873.—*Idem*, in the 'Field' for July 12, 1873.—*Garsin*, 'Histoire de l'Acad. des Sci.,' Paris, 1730, p. 44.—*Goodsir, J.*, "On *Gymnorynchus horridus*, a new Cestoid Entozoon," 'Edin. New Phil. Journ.,' p. 9, 1841.—*Houghton, W.*, "On the occurrence of *Gyrodactylus elegans* in Shropshire," 'Ann. Nat. Hist.,' 1862.—*Huxley*, "Note on Gyrodactylus," 'Proc. Roy. Inst.,' April 20, 1852, and 'Edin. New Phil. Journ.,' 1852, p. 172.—*Knoch, J.*, 'Entwickelungsgeschichte d. *Both. proboscideus*,' 1862.—*Knox, J. F.*, "Note respecting the occurrence of a peculiar Microscopic Entozoon in the Textures of the Herring," 'Lancet,' 1838.—

Kölliker, "Zwei neue Distomen," 'Ber. v. d. K. Zoot. Anstalt zu Würzburg,' 1849.—*Idem*, 'Ueber Tristoma,' *ibid.*, 1849.—*Leidy, J.*, "Notice of a Tetrarhynchus (*T. tenuicaudatus*) in the Remova;" 'Proc. Acad. N. S. Philad.,' Oct. 15, 1878; and in 'Ann. Nat. Hist.,' Feb., 1879.—*Leydig*, "Ueber Argulus," 'Sieb. und Köll. Zeitsch.,' 1850.—*Maddox, R. L.*, "Some Remarks on the Parasites found in the Nerves (and other parts) of the Common Haddock (*Morrhua æglefinus*)," 'Trans. of the Roy. Micr. Soc.,' 1867, p. 87.—*Menzies*, 'Linn. Trans.,' 1790, p. 187.—*Miescher*, "On *Filaria piscium*," &c., in 'Excerpta Zoologica,' communicated by Dr Frances, in 'Ann. Nat. Hist.,' 1842.—*M'Intosh, W. C.*, "Notes on the Food and Parasites of the *Salmo salar* of the Tay," 'Proc. Linn. Soc.,' 1863; repr. in the 'Zoologist,' Feb., 1864.—*Müller, J.*, "Note on a Parasitic Formation (Gregarina) in the Pike, with a statement from his 'Neurologie der Myxinoiden,' that *Diplostomum rachineum* is to be found alive under the cerebral membranes of *Petromyzon fluviatilis*," from 'Müller's Archiv,' in 'Micr. Journ. and Struct. Record,' p. 20, 1842.—*Nardo*, in 'Heisinger's Zeitsch.,' 1827, s. 68, and in 'Isis,' 1833, s. 523.—*Olsson, P.*, "Researches on the Flukes and Tapeworms chiefly of Marine Fishes," 'Entozoa, iakttagna hos Skandanaviska Hafsfiskar,' Lund (aftr. ur 'Lunds Univ. Årsskrift,' tom. iii, iv), 1867–68.—*Owen*, 'Zool. Soc. Trans.,' 1835, p. 382.—*Pallas*, 'Spicilegia Zoologica,' fasc. x, p. 18, 1774.—*Siebold, C. von*, 'Band und Blasenwürmer,' s. 41, Huxley's edit., p. 32.—*Idem*, "On *Diplozoon paradoxum*," from 'Zeitsch. f. wiss. Zool.' (by Huxley), in 'Ann. Nat. Hist.,' 1851.—*Idem*, "Ueber den Generationswechsel der Cestoden nebst einer Revision der Gattung Tetrarhynchus," 'Zeitschr. f. wiss. Zool.,' 1850, s. 198.—*Idem*, "Gyrodactylus, ein ammenartiges Wesen," *ibid.*, 1849.—*Slack, H. J.*, "On *Bucephalus polymorphus*," in 'Monthly Microsc. Journ.,' April, 1875, p. 141.—*Van Beneden* (see Beneden).—*Verrill, A. E.*, "On the Parasitic Habits of the Crustacea," from 'American Naturalist,' in 'Scientific Opinion,' Aug. 4, 1869, p. 185.—*Idem*, "New Flukes (*Tristoma læve* and *T. cornutum*) from the Mouth and Gills of *Tetrapturus albidus*," 'American Journ. of Science,' p. 40, 1875.—*Von Baer* (see Baer).—*Von Siebold* (see Siebold).—*Wagener, R. G.*, "Helminth. Bemerkungen," in 'Sieb. und Köll. Zeitsch.,' 1857.—*Idem*, "Enthelminthica," 'Müller's Arch.,' 1851.—*Idem*, "Ueber Eingeweidewurm (Amphiptyches)

in *Chimæra monstrosa*," 'Müll. Arch.,' 1852.—*Idem*, 'Beiträge zur Entw.-Gesch. der Eingeweidewürmer (Preisschrift),' 1857.—*Wedl*, "On Gyrodactylus" (see reference to my paper on '*G. elegans*'), 'Quart. Journ. Micr. Sci.,' 1862; trans. from his 'Anhang,' "Ueber die Gattung Gyrod.," to 'Anat. Beobachtungen ueber Trematoden,' Wien, 1858.—*Idem*, 'Hæmatozoa in Fishes,' &c. (l. c., Bibl. No. 58).—*Wigham, R.*, "Note on *Holostomum cuticola* from Roach and Bream," 'Ann. Nat. Hist.,' p. 235, 1851.—*Wilson, W. W.*, "On a Parasitic Worm infesting a Marine Fish (*Crenilabrus rupestris*)," in 'Science Gossip,' Jan., 1876.—*Yarrell, W.*, "Note on *Tristoma coccineum*," in his work on 'Brit. Fishes,' vol. ii, p. 353, 1836.

Part IV (Evertebrata).

Since a large proportion of all those helminths that require a change of hosts must needs pass into the bodies of insects, crustaceans, mollusks, or other evertebrated animals, it is evident that these lower creatures are almost as liable to be infested by parasites as the vertebrates themselves. As a rule, no doubt, the parasitic forms infesting individual evertebrated hosts are not numerous; nevertheless the water-snails form a noteworthy exception. Thus, some ten different species of parasite are found either in or upon the common *Planorbis corneus*; whilst *Lymnæus stagnalis*, *Paludina vivipara*, and *P. impura*, each support at least a dozen species. Of course, the parasites are not sexually mature, since nearly all of them are *Cercariæ* or larval trematodes. Snails, oysters, mussels, whelks, and other mollusks afford harbour and anchorage to a variety of parasites and messmates; but, fortunately, few or it may be none of the strictly human parasites require to pass through these intermediate bearers. *Distoma crassum* is possibly an exception. Save the cuttle-fishes, not many evertebrated animals are infested by sexually-mature worms. One of the most notable exceptions is that of a nematoid infesting bees. This worm was known to John Hunter, who spoke of it as "the animal that breeds in the humble bee." In the year 1836, M. Léon Dufour first applied the term *Sphærularia* to this remarkable worm, which he discovered in the abdominal cavities of two species of bee (*Bombus terrestris* and *B. hortorum*). The worm was subsequently found by Von Siebold in

two other species of bee (*B. muscorum* and *B. sylvarum*), but it remained for Sir John Lubbock to demonstrate that this parasite not only infests these insects, but also *Bombus lucorum, B. lapidarius, B. pratorum, B. subterraneus*, and *Apathus vestalis*. I possess specimens from *Vespa vulgaris* and *V. rufa*. Sir J. Lubbock and Mr. Cole have separately given full anatomical descriptions of the worm. According to Lubbock the so-called female is about an inch in length, of a whitish color, and $\frac{1}{15}''$ in thickness, being bluntly pointed at either extremity. *Sphærularia* is everywhere covered by small warts or button-like projections, in all numbering about 800. The warts are transparent, each, according to Lubbock, projecting from $\frac{4}{1000}''$ to $\frac{6}{1000}''$ above the general surface of the integument. There is neither mouth, œsophagus, intestine, nor

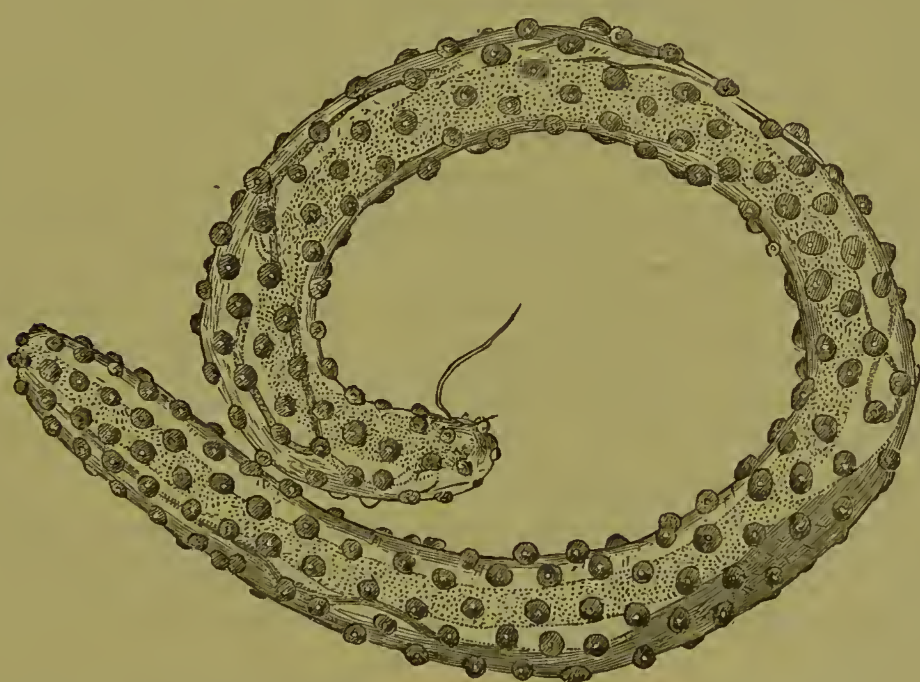

FIG. 85.—*Sphærularia bombi*. Showing the supposed male *in sitú*. After Lubbock.

anus ; but in their place a large fatty mass or *corpus adiposum*. Sir J. Lubbock remarks that this peculiar organ "is homologous, not with the whole intestinal canal of nematodes, but only with the intestine; and we find, in fact, that in Gordius the œsophagus is very short, and opens at once into the anterior end of the *corpus adiposum* ; so that to pass from this genus to *Sphærularia* it would be necessary to shorten the œsophagus a little more, and then the wall of the *corpus adiposum* would be immediately attached to that of the body. So far, therefore, as concerns the *corpus adiposum* and the

œsophagus, *Sphærularia* agrees neither with Gordius nor Mermis, nor, indeed, with one more than the other; since, if it agrees with *Mermis albicans* in the double series of large fat cells, it has no œsophagus, and in this respect more nearly resembles Gordius." The reproductive organs consist of a single ovary, uterus, and terminally situated vulva. These organs in the full-grown females contain ova in all stages of development up to the condition of advanced yolk segmentation; but it does not appear that embryonic formation takes place whilst the eggs are still *in utero*. "The young animals are born soon after the eggs are laid. They are about $\frac{1}{60}''$ in length, and $\frac{1}{2300}''$ in diameter at the broadest part. Before Sir J. Lubbock conducted his inquiries the so-called male appears to have been overlooked. The male, if male it be, is extremely minute; that is to say, about 28,000 times smaller than the female. Notwithstanding this very circumstantial account based on Lubbock's determinations, Schneider has sought to show that the facts have been entirely misinterpreted. What Lubbock regards as the male worm is, in Schneider's opinion, a female, whilst the so-called female is nothing more than a gigantic prolapsed uterus which has become many thousand times larger than the body of the worm whence it proceeded. It must be allowed that Schneider's description and accompanying figures are very convincing. When revising the entozoa of the Hunterian Collection in 1866 I explained the specimens and dissections in accordance with Lubbock's views. In the following year Prof. Huxley in his College Lectures supported the view of Schneider, but in his recently published manual the opinions of the Berlin helminthologist are not so much as alluded to.

Another point of special interest in connection with the parasites of insects concerns the development of *Mermis albicans*. At or near the time of the maturation of the ova, the parent worm, hitherto lodged within the body of some insect, buries itself in the soil. It commences its migration by boring its way out of the body of the host. Some difference of opinion exists as to the condition of the parent at the time of its wandering, for Von Siebold asserted that it quitted its parasitical mode of life "in order to become sexually mature away from the animal" infested; whereas Van Beneden states that the embryos are always formed at the time of the wandering.

From Von Siebold's experiments it would appear that in-

completely developed Mermes can become mature whilst still in the soil; but the normal condition requires the wandering to commence, as we have said, at or near the full time of embryonal development. The embryos are reproduced viviparously, and being set free, they pass a certain period of their existence in the soil. Here they grow rapidly, acquire sexual organs, and subsequently seek to "gratify their immigrative propensities," as Von Siebold says, by selecting and penetrating the soft-bodied larvæ of lepidopterous and other insects. This entrance they accomplish by means of a sharply-pointed dentule or boring stylet, which at the time of disuse is concealed within the head. Having once gained access to the host they remain within its body until the caterpillar has become transformed into the perfect butterfly, or until their own sexual maturity is completed. Van Beneden thinks it probable that the males quit the host some time before the females, a view which, if correct, might alone account for the comparative scarcity of the males. According to Von Siebold, sexual congress occurs before the entrance of the worm into the caterpillar. This observation agrees with the generally admitted fact that hitherto no male Mermes have actually been detected in the bodies of insects. The Gordii, like Mermes, become free in damp earth and penetrate the bodies of certain insects or their larvæ. Some of them gain access to fishes. Like the free nematodes (*Anguillulidæ*), many of the Gordii will survive complete desiccation. The eggs of the mature worms are deposited in long agglutinated chains in water or damp situations.

I must conclude. In the body of this work will be found many notices of insect parasites that are awaiting transference to some vertebrate. I need only allude to the rôle of the mosquito, to that of the louse of the dog, and especially to that of the little myriapod (*Glomeris*) which, like the common glow-worm (*Lampyris*), possesses phosphorescent properties. I mention this again partly in correction of an entomological error (at p. 296) which escaped me at the time of going to press. Leidy has described a mature nematode (*Ascaris infecta*) from *Passalus cornutus*, and numerous Filariæ are known to infest insects (*Blatta, Forficula, Phosphuga*, &c., &c.). From an earwig I obtained a filaria nearly five inches in length.

We have seen that the larvæ of *Dracunculus*, *Cucullanus*, as well as those of other important nematodes, dwell in bodies of entomostracous crustacea, whilst those of *Echinorhynchus* attack

the Gammari and their allies. The well-known *Udonella caligorum* attaches itself to crustacea that are themselves parasitic.

As many of the so-called free nematodes live in the slime of animals, Villot is of opinion that no very distinct line of demarcation can fairly be drawn between the parasitic and free species. This work, however, having dealt only with genuine parasites, I have purposely omitted any detailed account of the so-called free nematoids. I mention this lest it should be supposed that I had shown a studied neglect of the more or less remarkable labours of Bütschli, Bastian, Eberth, Linstow, Marion, Villot, Claus, De Man, Carter, and many others.

Bibliography (No. 60).—*Bastian, H. C.*, "Monograph on the Anguillulidæ, or free Nematoids, marine, land, and fresh-water, with description of 100 new species," 'Linnean Trans.' for 1865, vol. xxv, p. 73.—*Idem* (see Bibliog. No. 2).—*Idem*, "Free Nematoids," being an article in the 'Popular Science Review' for 1868, vol. vii, p. 163.—*Brady, G. S.*, 'Monograph of the free and semiparasitic Copepoda,' London, 1878.—*Bütschli, O.*, "Untersuchungen ueber freilebende Nematoden und die Gattung Chætonotus," 'Sieb. und Köll. Zeitschrift,' 1876.—*Carter, H. J.*, "On a Bisexual Nematoid Worm which infests the common House-fly (*Musca domestica*)," 'Ann. Nat. Hist.,' 1861, and in the 'Bombay Med. and Phys. Soc. Trans.,' new series, 1860.—*Claparède* (see Panceri).—*Claus, C.*, 'Beobachtungen ueber d. Organis. und Fortpflanz. v. *Leptodera appendiculata*,' 1869.—*Cobbold*, "Note on Insect Parasites," in 'Rep. of Entomological Club,' in the 'Midland Naturalist,' March, 1878, p. 80.—*Cole, W.*, "Remarks on a Parasite of Humble Bees," in 'Journal of the Quekett Microscopical Club,' 1875.—*Dufour, L.*, "Sphærularia," 'Ann. des Sci. Nat.,' 1836.—*Dujardin*, "On Mermis," 'Ann. des Sci. Nat.,' 2e sér., tom. 18, p. 129.—*Eberth* (see Bibliog. No. 2).—*Garner, R.*, "Note on a Distoma," in his paper 'On the Lamellibranchiate Conchifera,' 'Trans. Zool. Soc.,' 1841.—*Ghaleb, O.*, "Observations and Experiments on the Migrations of *Filaria rhytipleurites*, a Parasite of Cockroaches and Rats," 'Comptes Rendus,' July 8, 1878, and 'Ann. Nat. Hist.,' Aug., 1878.—*Idem*, "Note sur l'anat. et les migrations de deux Nématoides parasites, le *Pœcilogaster blatticola* et *Fil. rhytipl.*," Paris, 1876 (quoted by O. von Linstow).—*Giard, M. A.*, "On the parasitic Isopoda of the genus Entoniscus (infesting Crustacea)," from 'Comptes Rendus,' Aug., 1878, in 'Ann. Nat. Hist.,' Otc.,

1878.—*Idem*, "On the Orthonectida, parasitic on Echinodermata and Turbellaria (Rhopalura)," 'Ann. Nat. Hist.,' Feb., 1878.—*Grube, A.*, "On Cyclops as a new Cestoid-bearing Host," from 'Zoologisch. Anzeiger,' Bd. i, s. 74, in 'Journ. Royal Microsc. Soc.,' Nov., 1878, p. 254.—*Hunter, J.*, "Filaria of the Bee," in 'Catal. (by Owen) of the contents of the Mus. Royal Coll. Surg.,' part iv, fasc. i, p. 37, 1830.—*Kynston*, "Worms attached to a Grasshopper," 'Proc. Ashm. Soc.,' in 'Corbyn's India Review,' and in 'Journ. of Foreign Sci.,' 1837, p. 172.—*Lima, J. F. da S.*, "Remarks on the *Filaria medinensis* or Guinea-worm; on the occurrence of this parasite in the Province of Bahia; and on its entrance into the human body by drinking water;" trans. from the Portuguese by Dr J. L. Paterson, and pub. in the 'Veterinarian' for Feb., 1879 *et seq.*—*Linstow*, "Helminthologische Beobachtungen," in 'Archiv für Naturgeschichte,' 1876.—*Lubbock, Sir J.*, "On *Sphærularia bombi*," 'Nat. Hist. Rev.,' 1861.—*Idem*, "Notes," &c., *ibid.*, 1864, p. 265.—*Mason, J. W.*, "Note on the Geographical Distribution of the *Temnocephala chilensis* (parasitic upon a freshwater crayfish, *Paranephrops setosus*, in New Zealand)," 'Annals Nat. Hist.,' 1875, p. 336.—*Marion, A. F.*, 'Revision des Nématodes (&c.),' Marseilles.—*Maund, B.*, "A description of *Filaria forficulæ*," 'Rep. Proc. Linn. Soc.,' in 'Zool. Journ.,' 1832–34, p. 263.—*Meissner* (see Thomson).—*Owen, R.* (see Hunter).—*Pagenstecher* (see Bibl. No. 58).—*Panceri, P.* (e di E. D. Claparède), "Nota sopra une alciopide parassito dell *Cydippe densa*," 'Mem. della Soc. Ital. di Sci. Nat.,' 1867.—*Sars*, "Intestinal Worm in an Acaleph.," from 'Wiegmann's Archiv,' in 'Ann. Nat. Hist.,' 1845.—*Siebold, C. J. von*, in 'Wiegmann's Arch.,' 1835.—*Idem*, in 'Ray Soc. Rep.' (by Busk), 1847.—*Idem*, "Worms," &c., *ibid.*, p. 503, 1847.—*Idem*, "Report on Helminthology, and on the Nemertinæ" (trans. by W. B. Macdonald, in 'Ray Soc. Rep. on Zool.,' 1842, p. 280), Edinburgh, 1845.—*Idem* (see Thomson).—*Thomson, A.* (for review of the writings of Meissner, Von Siebold, and others, respecting the development of Mermis, Gordius, &c., see the classical and elaborate art. "Ovum"), in 'Supp. to Todd's Cyclop.,' 1859.—*Vogt, C.*, "On some Inhabitants (Cercariæ) of the Fresh-water Mussels," from 'Ann. des Sci. Nat.,' in 'Ann. Nat. Hist.,' 1850.—*Whitman, C. O.*, "The Embryology of Clepsine (with valuable Bibliography)," 'Quart. Journ. Micr. Sci.,' July, 1878.

Appendix.—The memoirs announced by Dr T. R. Lewis in the January issue of the 'Microscopical Journal,' and referred to at the close of my account of *Filaria Bancrofti,* having appeared, I fulfil the promise previously made (p. 202). In the few lines at my disposal I may observe that the beautiful brochure (quoted below) supplies fuller details of the results already announced by Lewis in the 'Proceedings of the Asiatic Society of Bengal.' In respect of the nematoid hæmatozoa, the memoir is chiefly important as confirming Manson's observations regarding the changes undergone by the Filariæ that have been transferred to the stomach of the mosquito, and especially also, as advancing some novel facts in reference to the occurrence of bird's blood-corpuscles, associated with embryonic nematoids, in the same viscus of the insect. The worms are regarded by Lewis as transferred avian hæmatozoa, a view which gains strength by their comparison with the similar larvæ which he had detected in the blood of Indian crows (*Corvus splendens*). In Egypt, as Sonsino had himself informed me by letter, similar hæmatozoa are to be found in crows, and avian filariæ of this kind were long previously described, as Lewis and Sonsino point out, by Borell, Herbert, Schmidt, and Virchow. Facts of this order undoubtedly complicate matters, and suggest that extreme measure of caution in drawing conclusions, which Lewis himself everywhere displays.

Respecting the final changes undergone by the mosquito-filariæ before their re-entrance into the human body, Lewis does not appear to have gone further than Dr Manson. By rupturing the body of the most advanced larvæ, Lewis readily recognised the œsophagus and intestine, but he remarks, significantly, "I have not been able to distinguish any other differentiated viscus in any of the specimens, and certainly, nothing suggestive of differentiation of sex" (p. 83). In an earlier part of the memoir Dr Lewis takes objection to my view that the urinary nematoids found by me in a case of Bilharzia are genetically related to *Filaria sanguinis hominis.* His distinguished coadjutor, Dr D. Cunningham, also denies the possibility of such relationship. No doubt, if the urinary maternal worm was really oviparous my view is untenable; but the proved presence of imperfectly formed ovarian ova, in which no trace of embryonic formation was discernible, has forced upon me the conviction that prolapsus and rupture of the uterine tubes of the parent worm had occurred, and that their rupture had occasioned the escape

of ova in various stages of growth. As free embryos were also detected, the adult worm was probably viviparous. There is an error in the representation of the oval-shaped ovum given in the figure (p. 183). I retain drawings of eighteen perfect nematoid ova from the Bilharzia case, and not one of these shows any double contour of the chorional envelope. In the case of the imperfect ova, the double contour is obviously due to the close apposition of the yelk-membrane to the shell-membrane, there being no true shell. As regards "a correction" which Lewis makes in respect of the question of priority of description of the mature *Filaria sanguinis hominis* I can only find space to state frankly, that Lewis is perfectly correct. The error was quite unintentional on my part. The adult worm was first discovered by Bancroft, and upon the strength of his admittedly scanty record I named the worm *Filaria Bancrofti*. In the matter of supplying a proper diagnosis and an anatomical description I was completely anticipated by Lewis. No doubt, Dr Bancroft could have furnished a fuller description of the parasite, had he desired to do so, but here is what he says in the letter addressed to me from Melbourne on the 20th of April, 1877 :—"I thought it better to send you this account of filariæ than to publish it *direct*, as you so kindly set me on the track of the investigation." Here I feel constrained to remark that few, if any, of my many correspondents in helminthology, have displayed more engaging candour. Whilst actually writing this Appendix (April 15th, 1879) I have received a new record of filarious cases from Dr Bancroft, who also sends me some mosquitoes captured by a victimised patient whose blood swarmed with filariæ. In one of the captured insects Bancroft himself detected forty-five filariæ. The cases have been forwarded to the 'Lancet' for publication. Lastly, in reference to the closing paragraph of Bancroft's previous letter to me (pub. in the 'Lancet,' Feb. 1st), I have received the following interesting commentary at the hands of Dr Silva Araujo, whose letter is dated from Bahia, March 3rd, 1879 :—"Je dois vous communiquer que ce fait vient confirmer l'idée qui existe chez nous, où le peuple croit et affirme que—quand une personne qui souffrait auparavant d'erysipèle a un abcès cela la préserve de nouveaux accès. La raison ne sera-t-elle pas que dans ce cas, avec l'ouverture de l'abcès, le ver sort ? Je le crois. Ces faits viennent démontrer que la cause de la maladie est le ver. Cependant nous avons ici à Bahia plusieurs con-

frères qui ne le croient point! Et à Rio-de-Janeiro aussi il y en a, peut-être davantage (!)." I will only add that Dr Araujo deceives himself if he imagines that the full etiological significance of parasites in relation to disease will receive general professional recognition for many years to come.

SUPPLEMENT TO BIBLIOGRAPHY No. 23, p. 202 (with emendations).—*Araujo*, 'Memoria sobre a Filariose ou a molestia produsida por uma nova especie de parasita cutaneo,' Bahia, 1875. —*Idem*, "Da filariose," 'Globo,' Jornal do Rio de Janeiro, 1876, e 'Revista Medica do Rio de Janeiro,' 1876, anno 3o, No. 2, 15 de Julho, p. 107.—*Idem*, "Caso de chyluria, elephancia do escrôto, escrôto lymphatico, craw-craw e erysipela em um mesmo individuo; descobrimento da Wuchereria filaria na lympha do escrôto. Tratamento pela electricidade com excellentes resultados," 'Gaz. Med. da Bahia,' 2a serie, vol. 2o, No. 11, Nov. de 1876.—*Idem*, "A *Filaria Wuchereri* no sangue," 'Gaz. Med. da Bahia,' Mar. de 1878, p. 106, e seguintes.—*Idem*, "A muriçoca e as filarias Wuchereri," 'Gaz. Med. da Bahia,' Setembro de 1878.—*Idem*, "La *Fil. immitis*," &c., Transl. of Mem. (*l. c.*, Bibl., No. 45) in 'Lyon Médical,' Nov., 1878, p. 319 et 363.—*Bancroft*, "Instance of a European having taken leprosy in Queensland," in a letter to myself; see "Case from Bancroft," quoted at p. 203.—*Chassaniol, A.* (et *F. Guyot*), "Hématurie graisseuse ou chyleuse," in their "Notes de Géographie Méd. recueillies à Taïti," in 'Archives de Méd. Navale,' Jan., 1878, p. 65.—*Cobbold*, "Worms in the Heart of Dogs," letter in the 'Lancet,' April 5, 1879, p. 498.—*Coles*, "On Lymph-scrotum," 'Brit. Med. Journ.,' March 9, 1878.—*Fayrer, Sir J.*, "Lecture on Elephantiasis Arabum," in the 'Lancet,' March 29, 1879, p. 433.—*Idem*, 'Report of Pathol. Soc.,' 'Lancet,' Feb. 22, 1879, p. 267.—*Idem*, 'Rep. of Epidemiological Soc.,' *ibid.*, p. 269.—*Idem*, 'Letter on Filaria;' see *Hoysted.*—*Ghaleb, O.* (with P. Pouquier), "On *Filaria hæmatica*," from 'Comptes Rendus,' Feb. 5, 1877, in 'Annals Nat. Hist.,' April, 1877.—*Hoysted, J.*, "Notes of a Case of *Filaria sanguinis* in a Dog;" see Bibliog. No. 49, p. 311.—*Lewis, T. R.*, 'The Microscopic Organisms found in the Blood of Man and Animals, and their relation to Disease,' Calcutta, 1879.—*Idem*, "The Hæmatozoa of Man (excerpt of the above)," 'Quart. Journ. of Microsc. Sci.,' April, p. 245 (both from '14th Ann. Rep. of the San. Commissioner with the Govt. of India').—*Makuna*, 'Letter respecting *Fil. sang. hom.* in Chyluria' (l. c., Bibliog. No. 23).

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